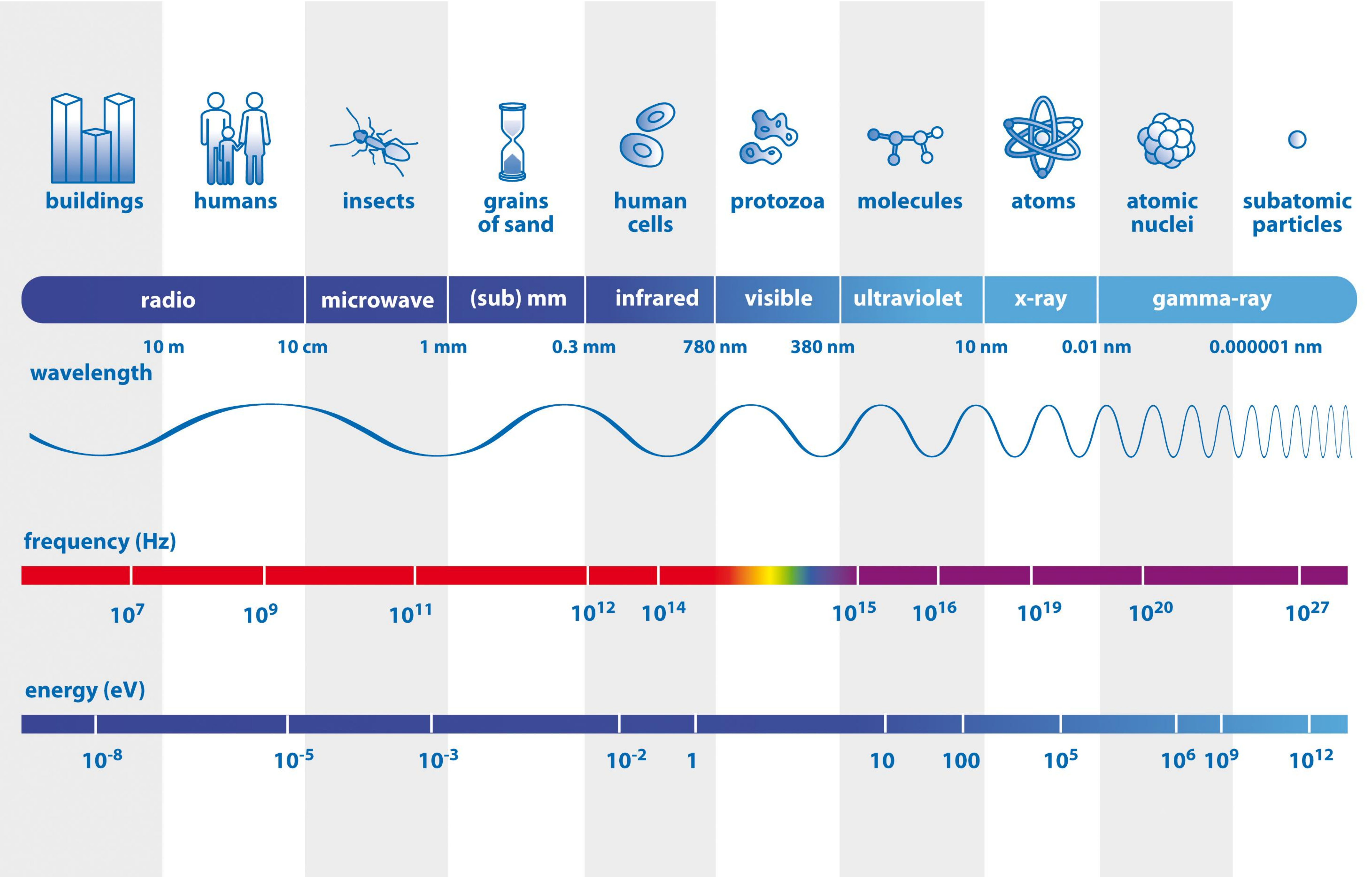
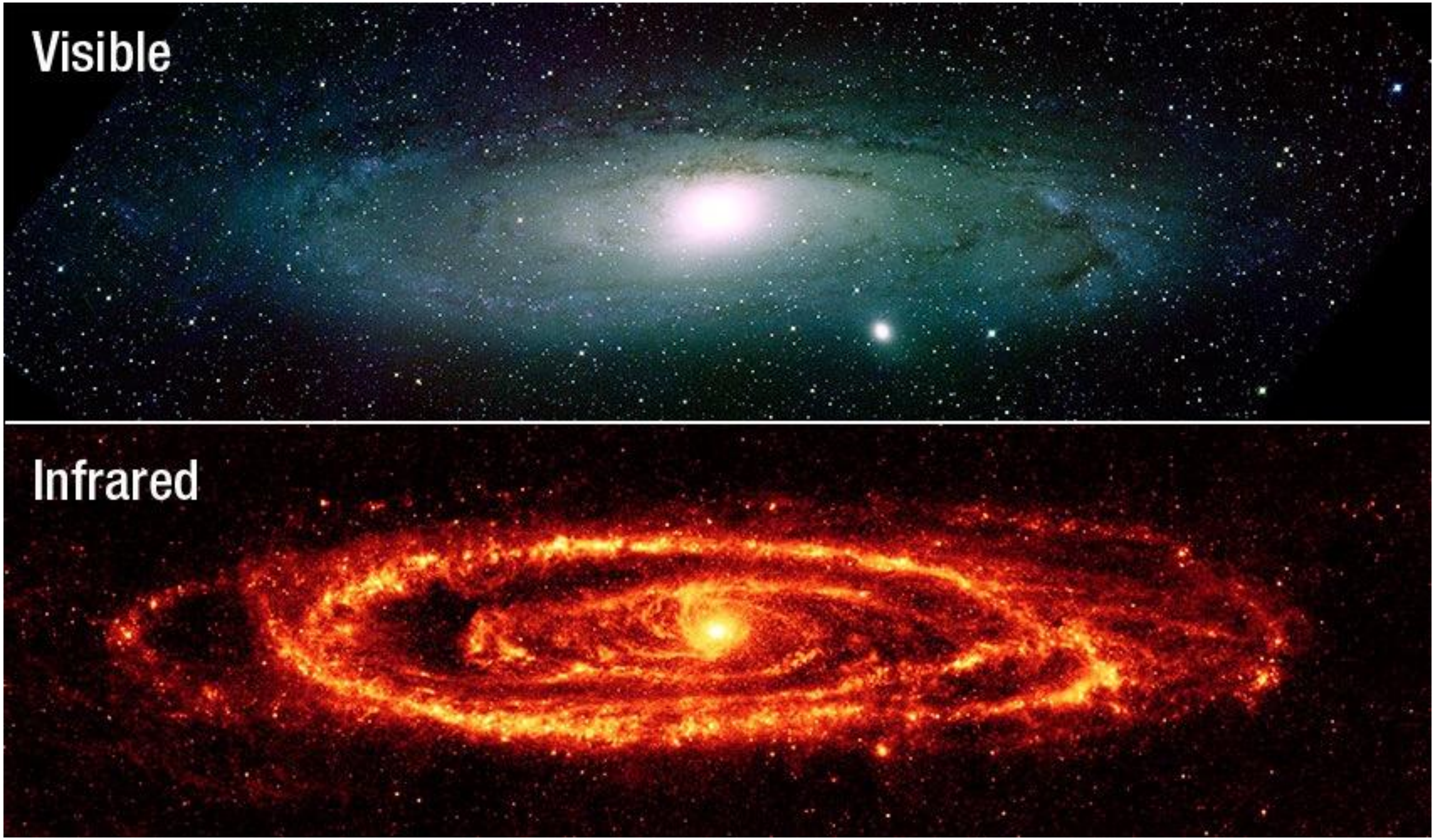
La missione spaziale XMM-Newton per l’astronomia X

Il progetto EXTraS

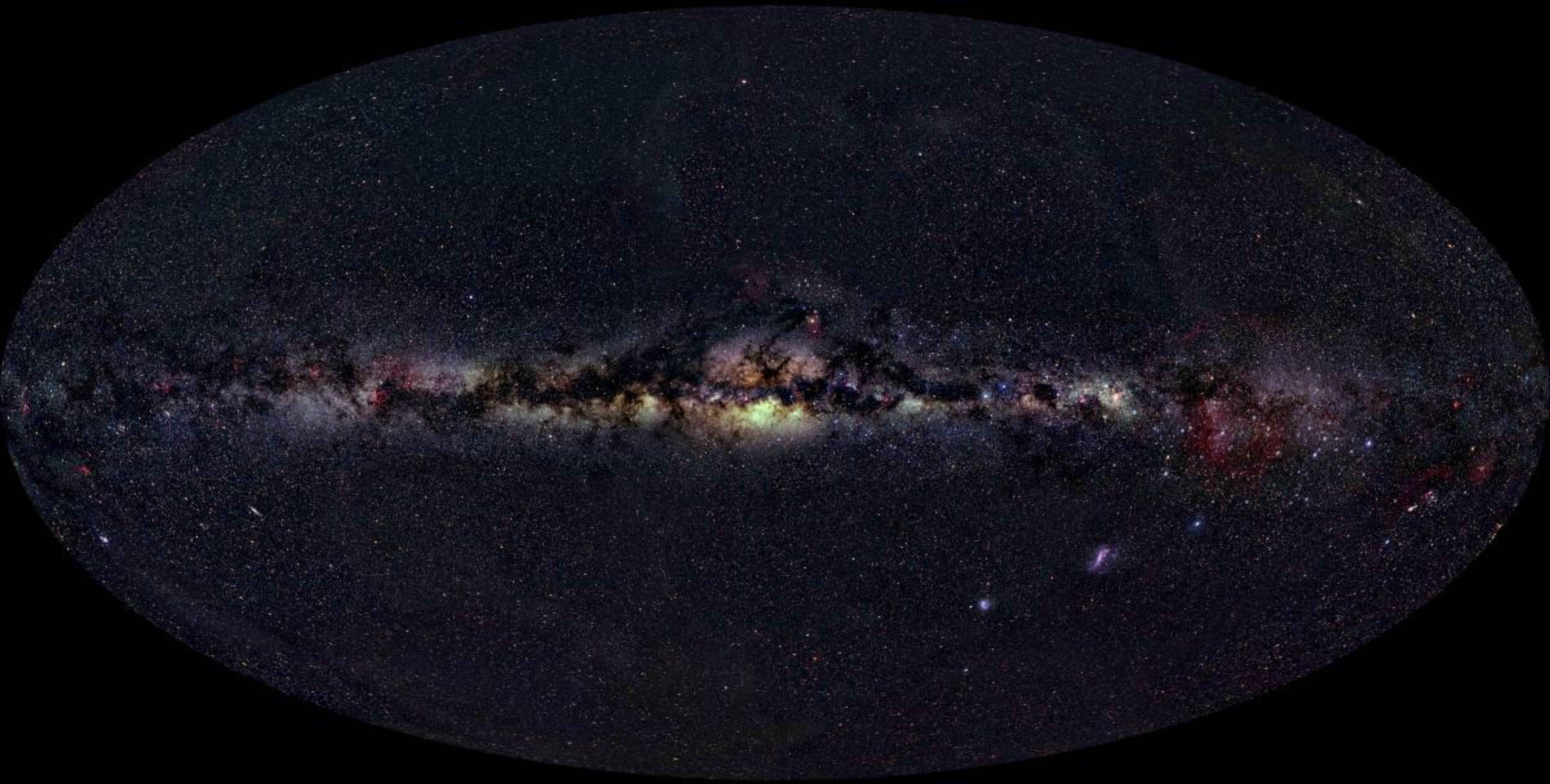

esa
XMM-Newton

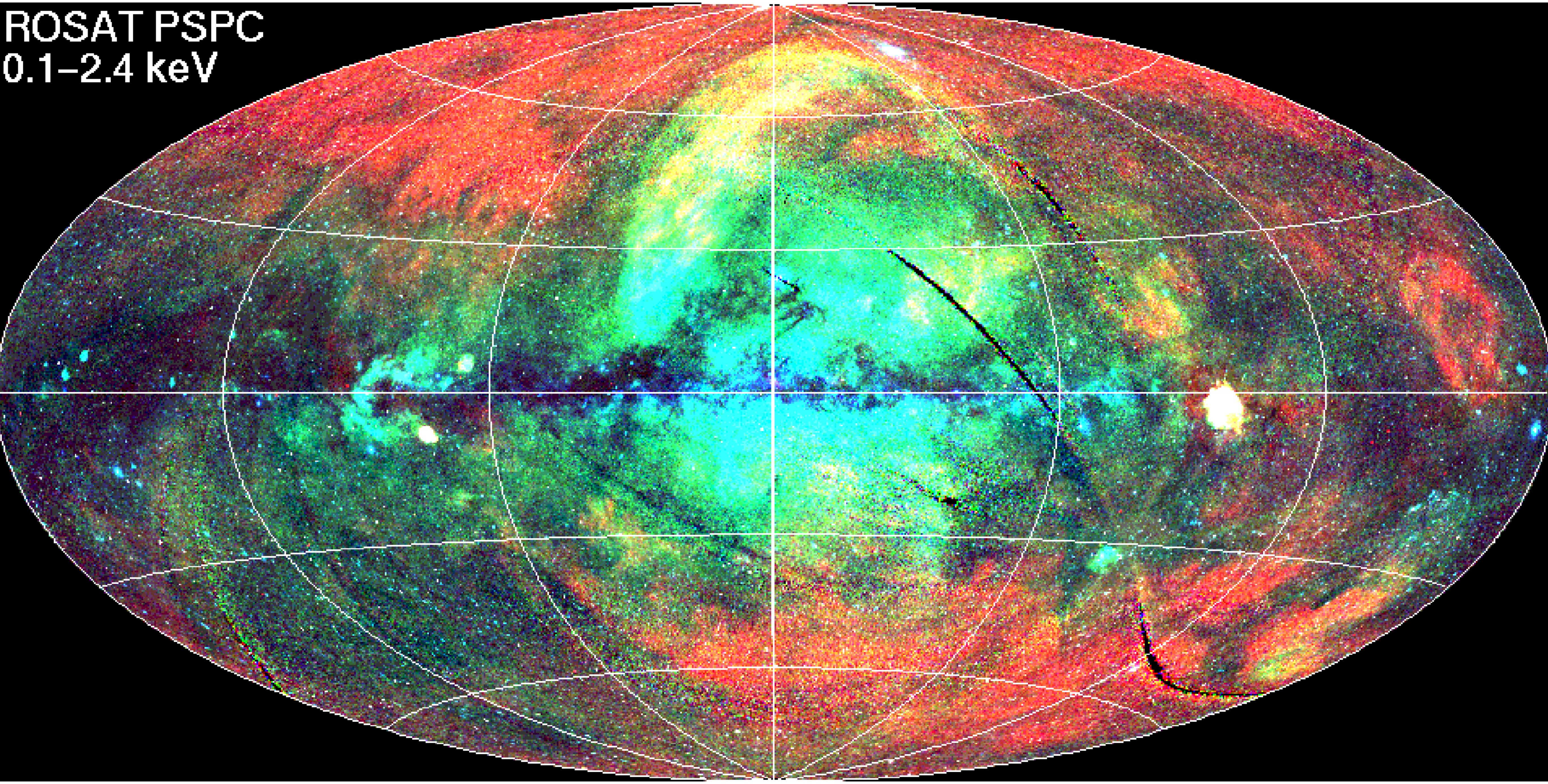

buildings
humans
insects
grains of sand
human cells
protozoa
molecules
atoms
atomic nuclei
subatomic particles
radio
microwave
(sub) mm
infrared
visible
ultraviolet
x-ray
gamma-ray
10 m
10 cm
1 mm
0.3 mm
780 nm
380 nm
10 nm
0.01 nm
0.000001 nm
wavelength
frequency (Hz)
10^7
10^9
10^{11}
10^{12}
10^{14}
10^{15}
10^{16}
10^{19}
10^{20}
10^{27}
energy (eV)
10^{-8}
10^{-5}
10^{-3}
10^{-2}
1
10
100
10^5
10^6
10^9
10^{12}

La galassia di Andromeda



The Deep Sky

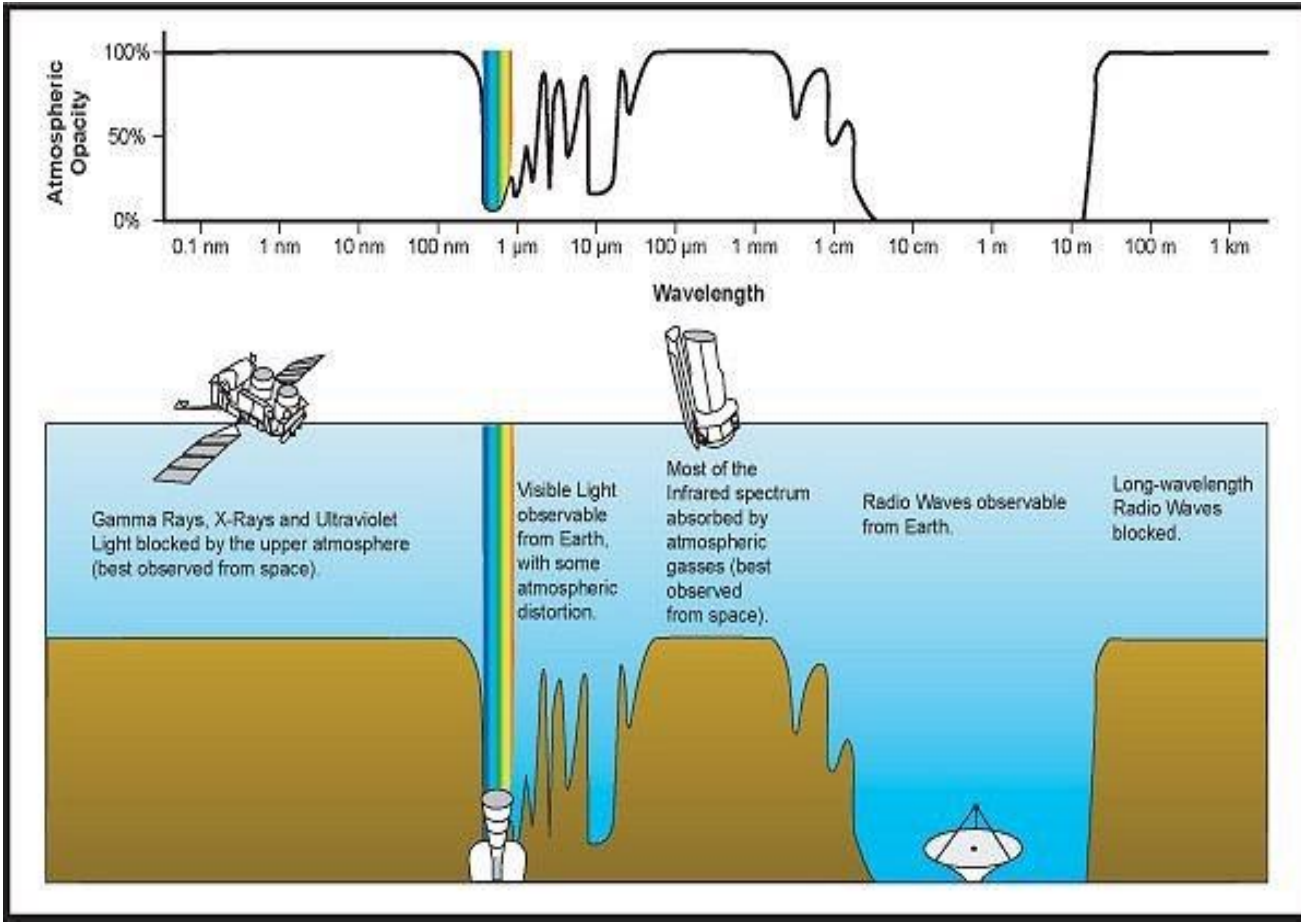



ROSAT PSPC
0.1–2.4 keV

Perseus cluster of galaxies

X-rays

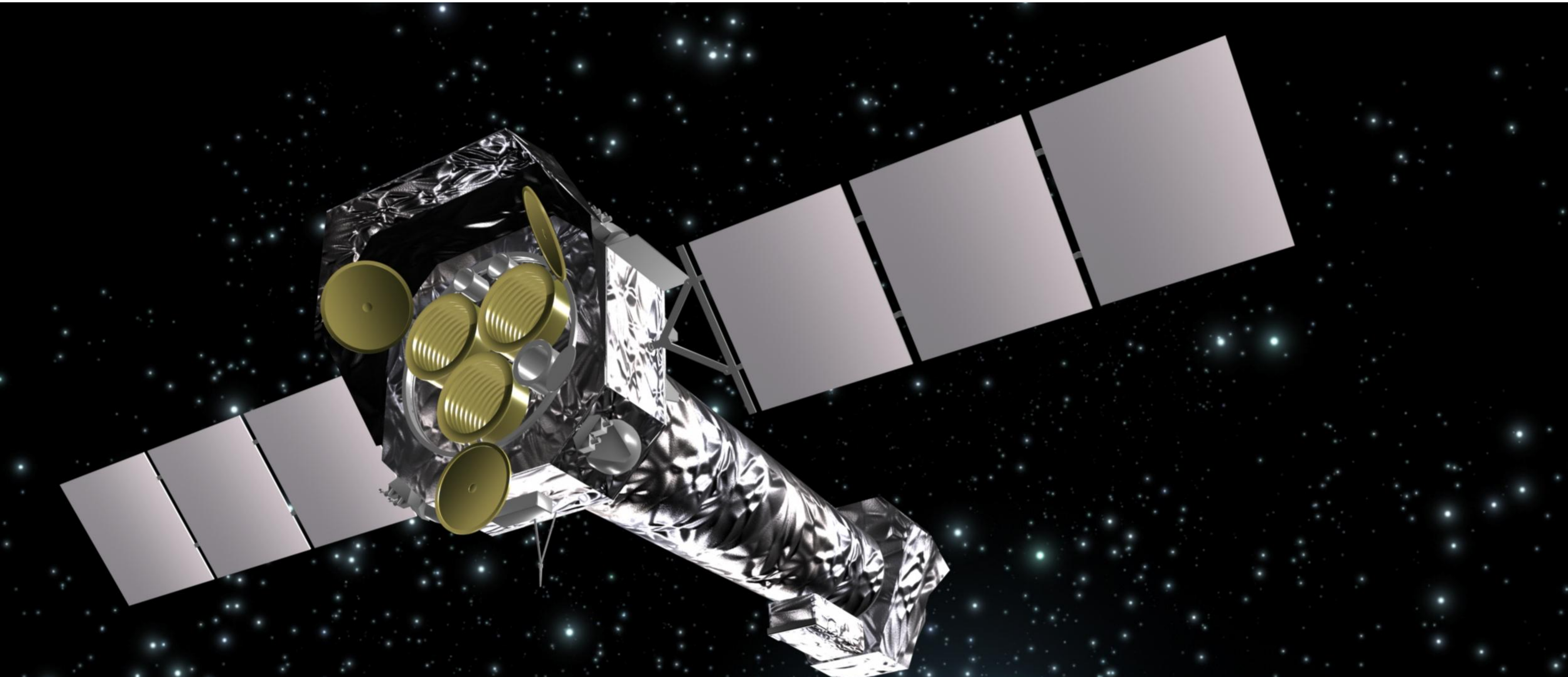
visible light


Atmospheric Opacity
100%
50%
0%
0.1 nm
1 nm
10 nm
100 nm
1 µm
10 µm
100 µm
1 mm
1 cm
10 cm
1 m
10 m
100 m
1 km
Wavelength
Gamma Rays, X-Rays and Ultraviolet Light blocked by the upper atmosphere (best observed from space).
Visible Light observable from Earth, with some atmospheric distortion.
Most of the Infrared spectrum absorbed by atmospheric gasses (best observed from space).
Radio Waves observable from Earth.
Long-wavelength Radio Waves blocked.

La missione XMM-Newton

- proposed in 1984
- approved in 1985;
- project team was formed in 1993
- development work began in 1996.
- constructed and tested from March 1997 to September 1999.

- launched in Dec 1999
- in-orbit commissioning started Jan 2000
- first images were published Feb 2000
- still fully operational



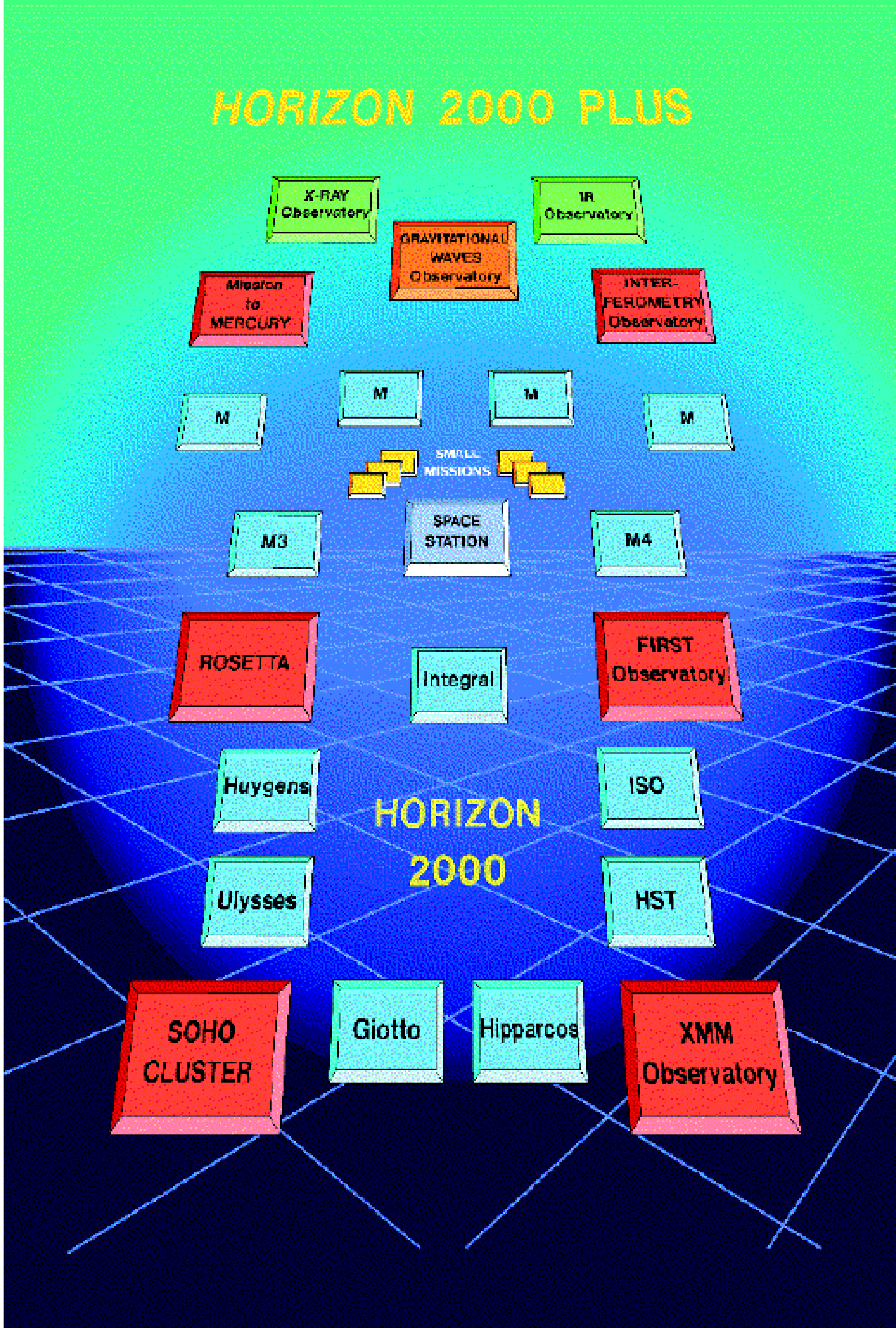
Cornerstone mission

nel programma di lungo termine

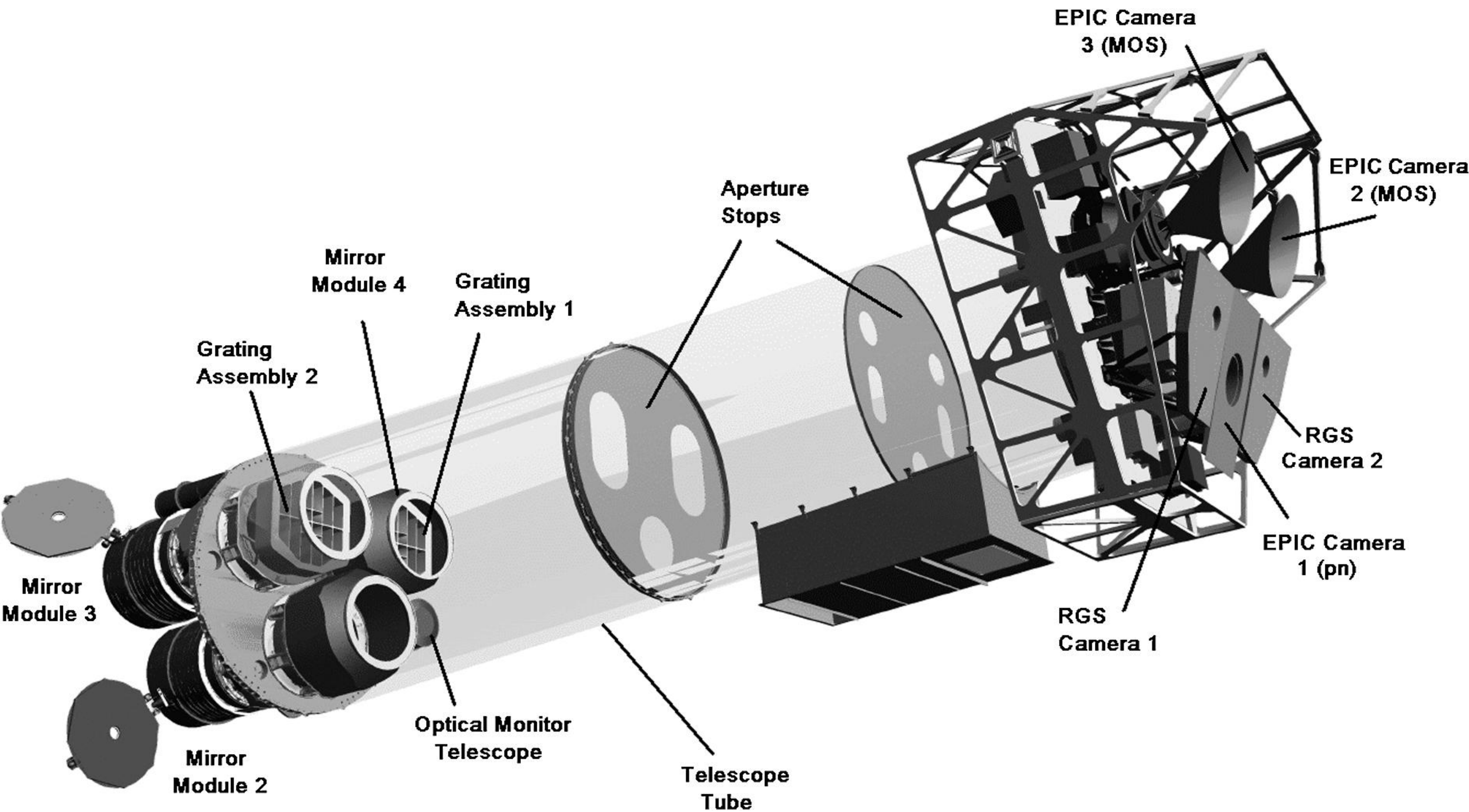
Horizon 2000 dell'ESA

http://xmm.esac.esa.int

http://sci.esa.int/xmm-newton/

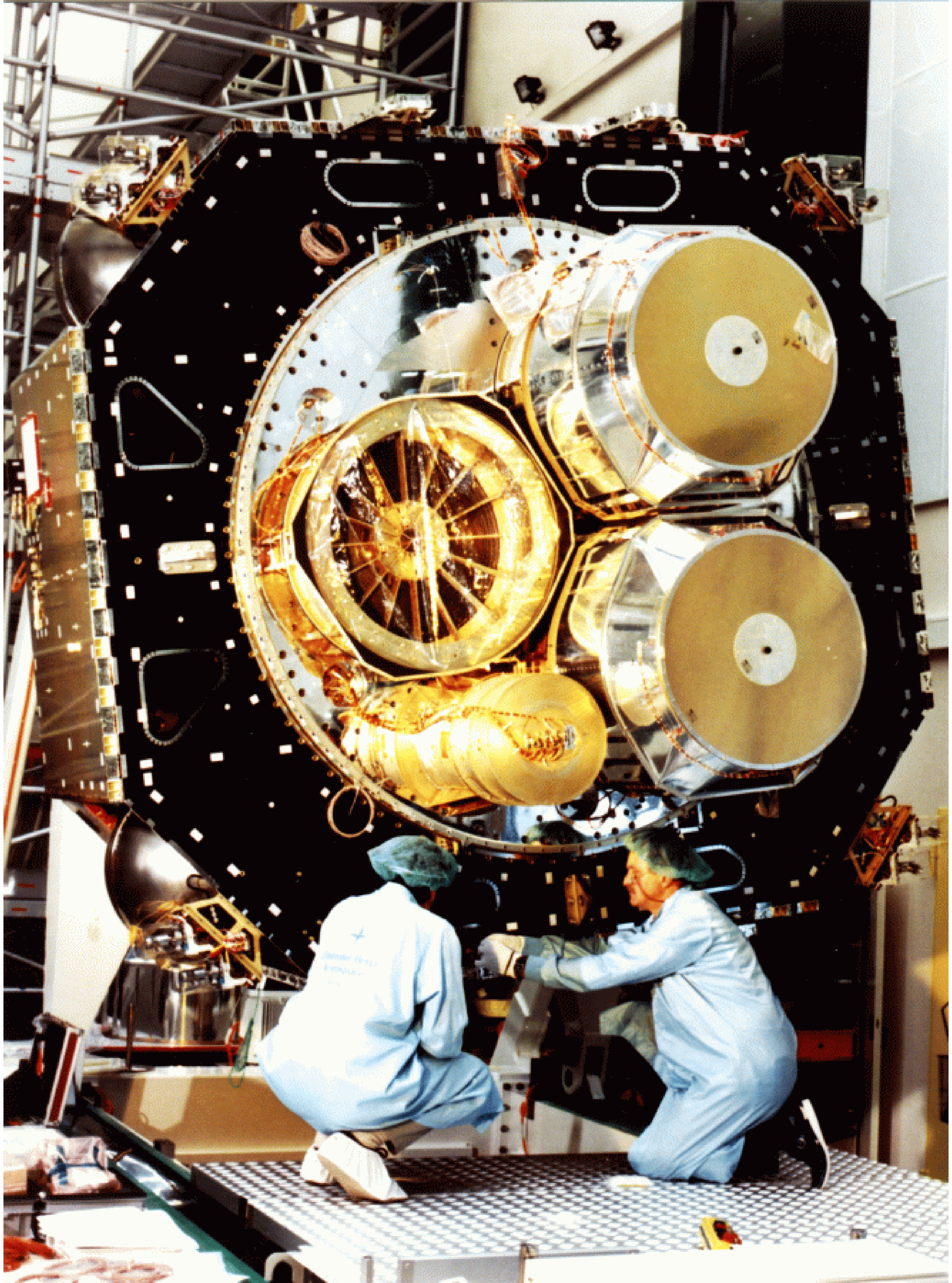


Come e' fatto XMM-Newton



XMM 3D model

http://sci.esa.int/xmm-newton/31382-3d-model/

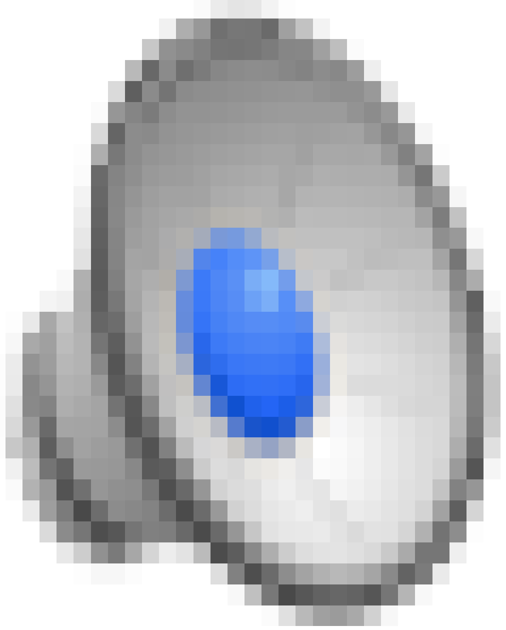


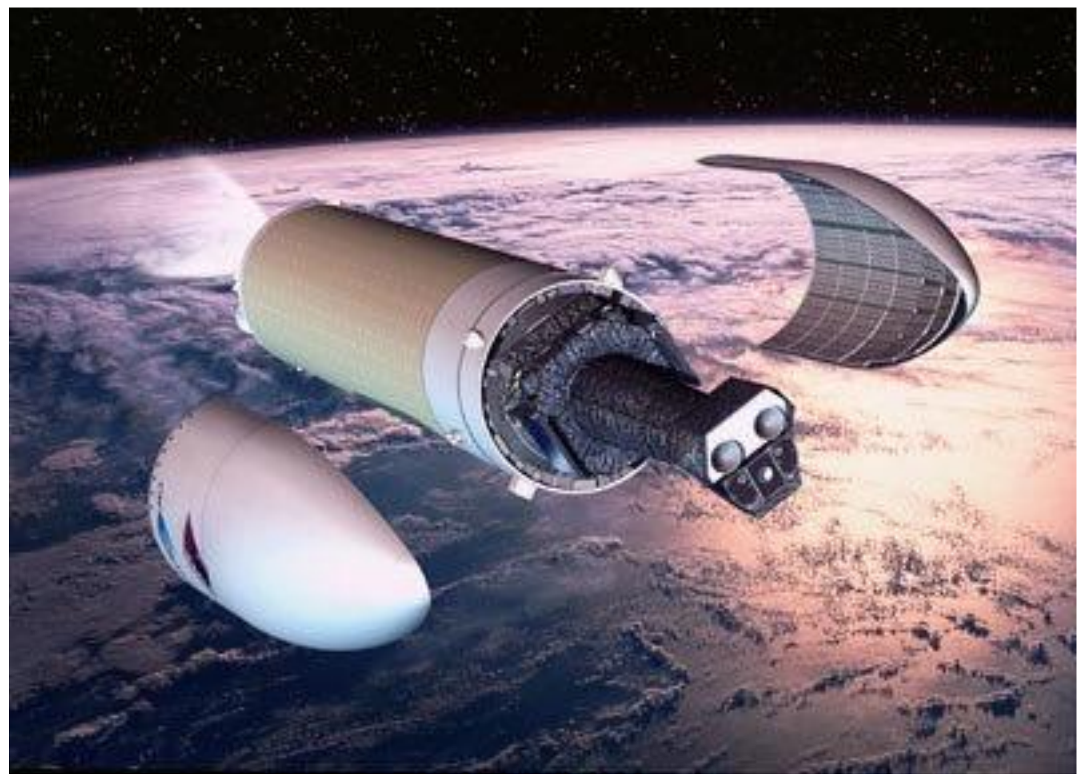

ADCO

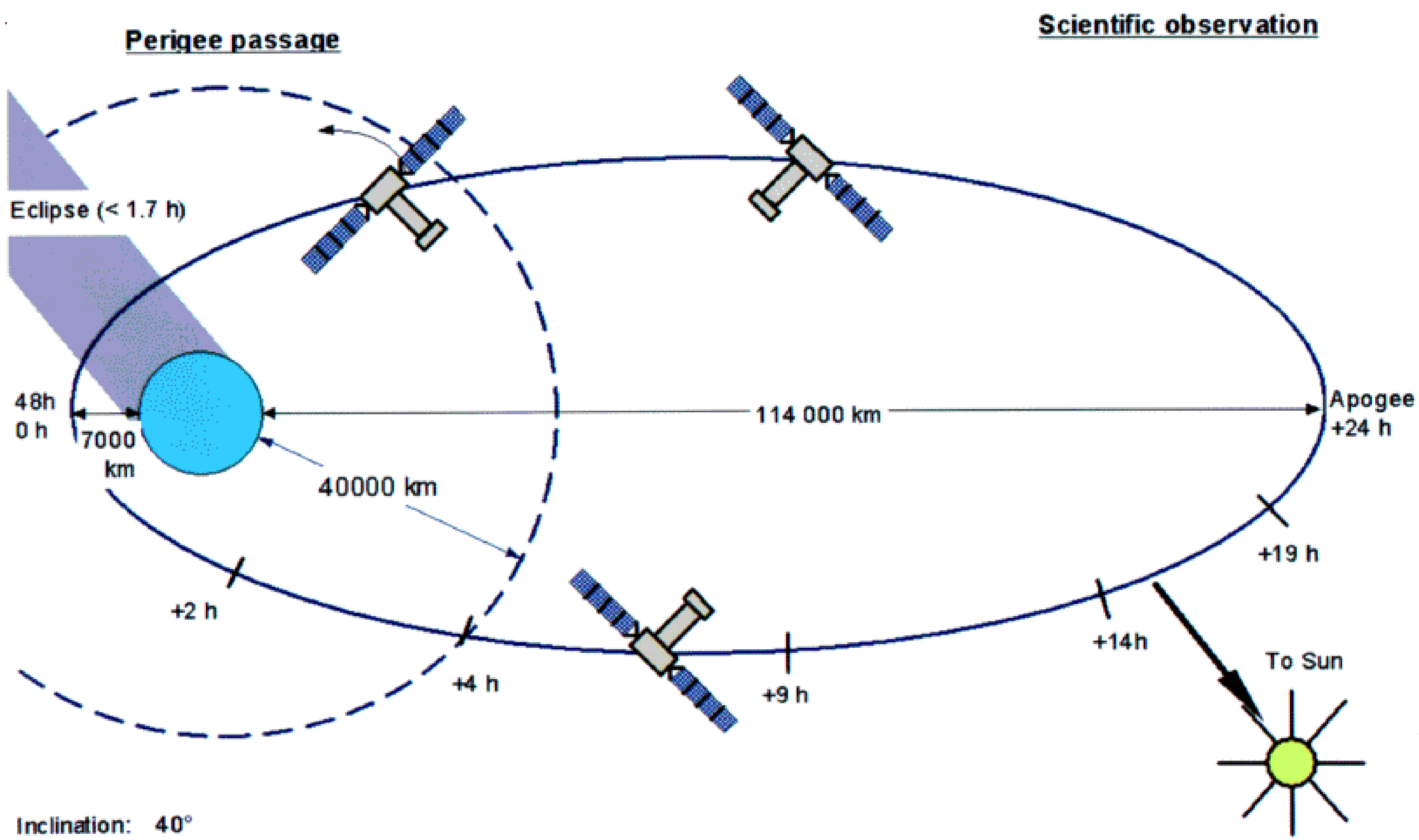

YTO
2354
ADCO

Video time: the launch

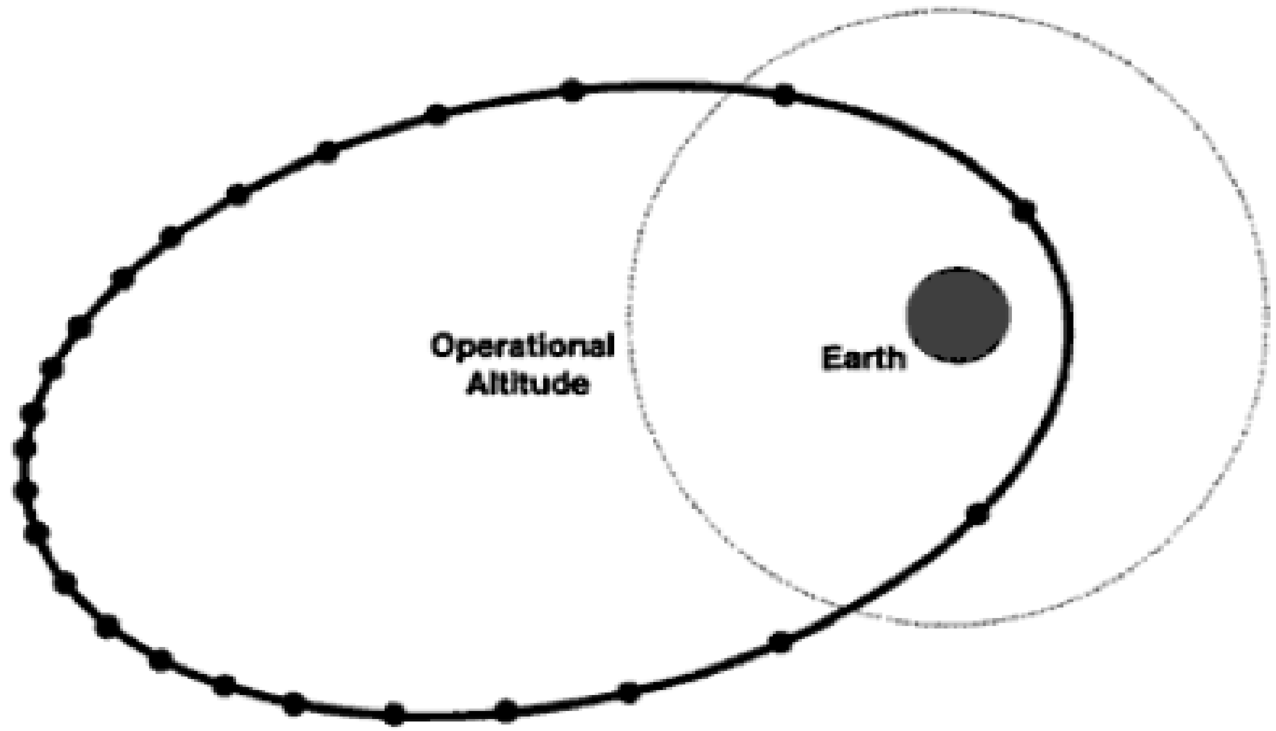
http://www.esa.int/spaceinvideos/Videos/2005/05/Stories_from_XMM-English



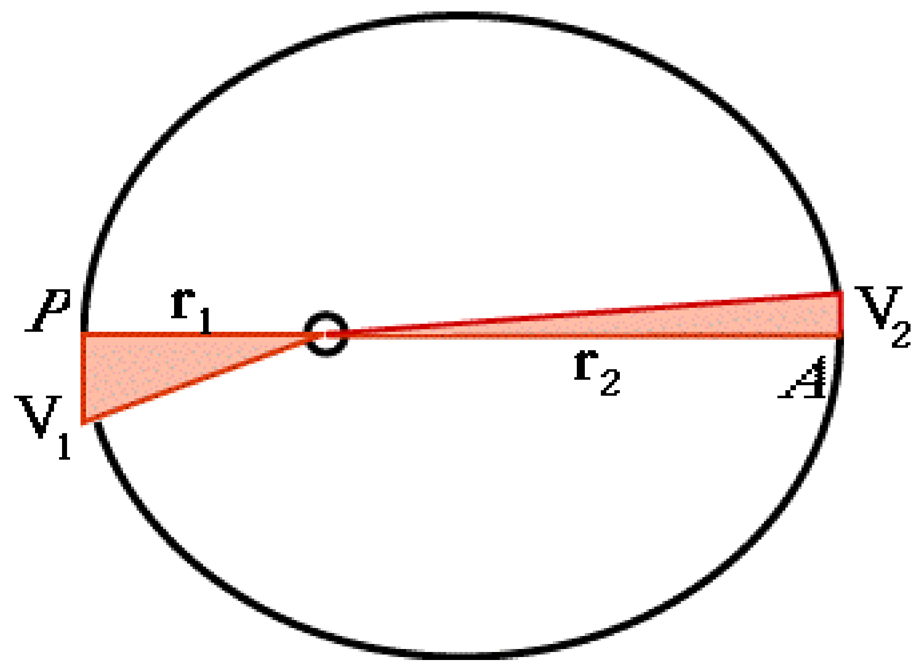




Perigee passage
Scientific observation
Eclipse (< 1.7 h)
48h
0 h
7000
km
40000 km
114 000 km
Apogee
+24 h
+19 h
+14h
+9 h
+4 h
+2 h
To Sun
Inclination: 40°

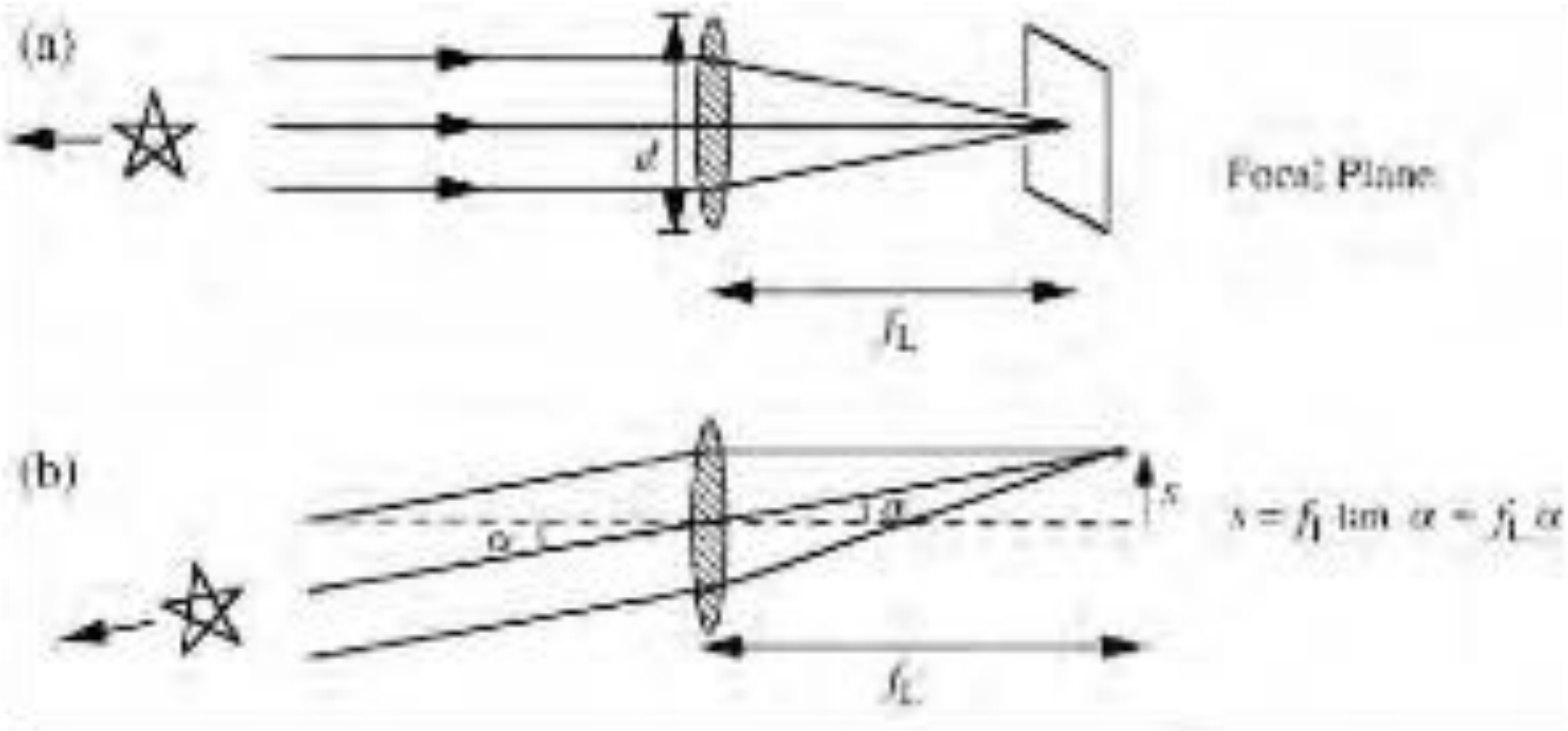


Operational Altitude
Earth

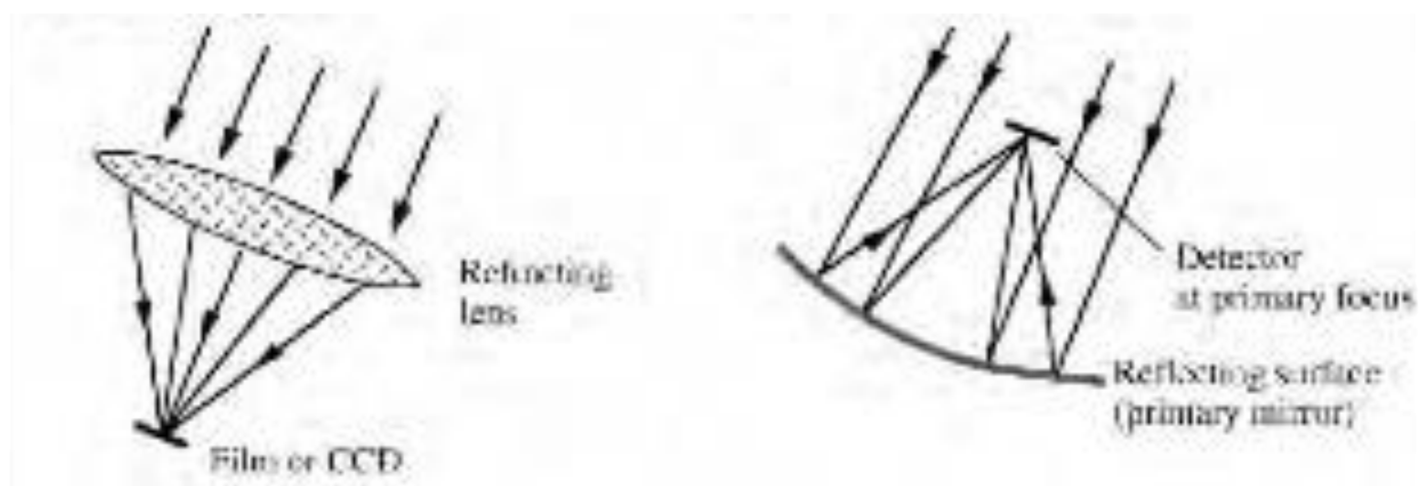


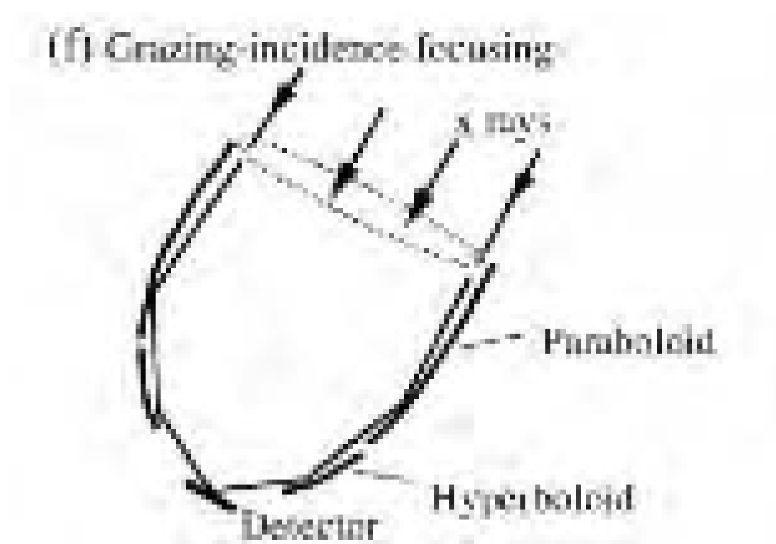
P
r1
V2
r2
A
V1

Formazione immagini in un telescopio

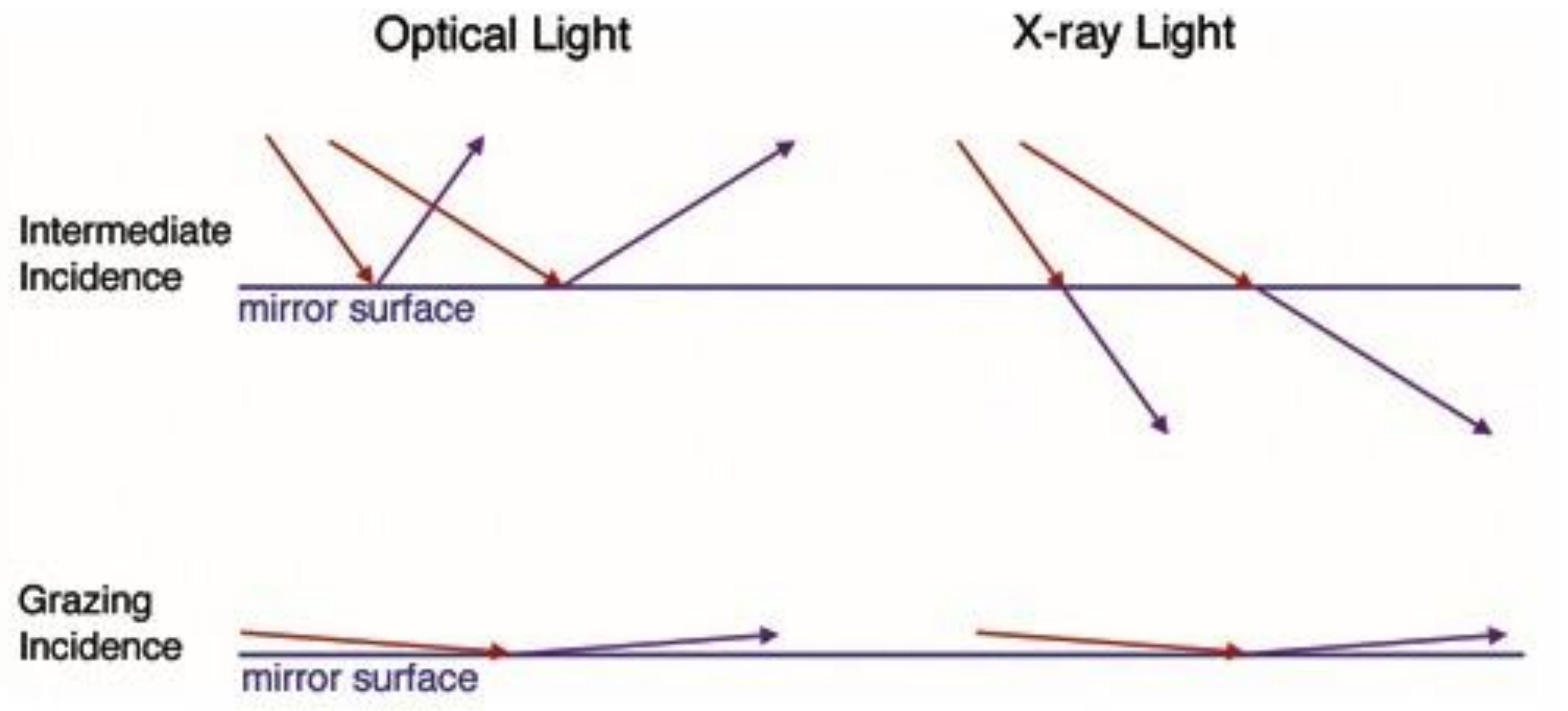


Diversi disegni ottici per diversi telescopi

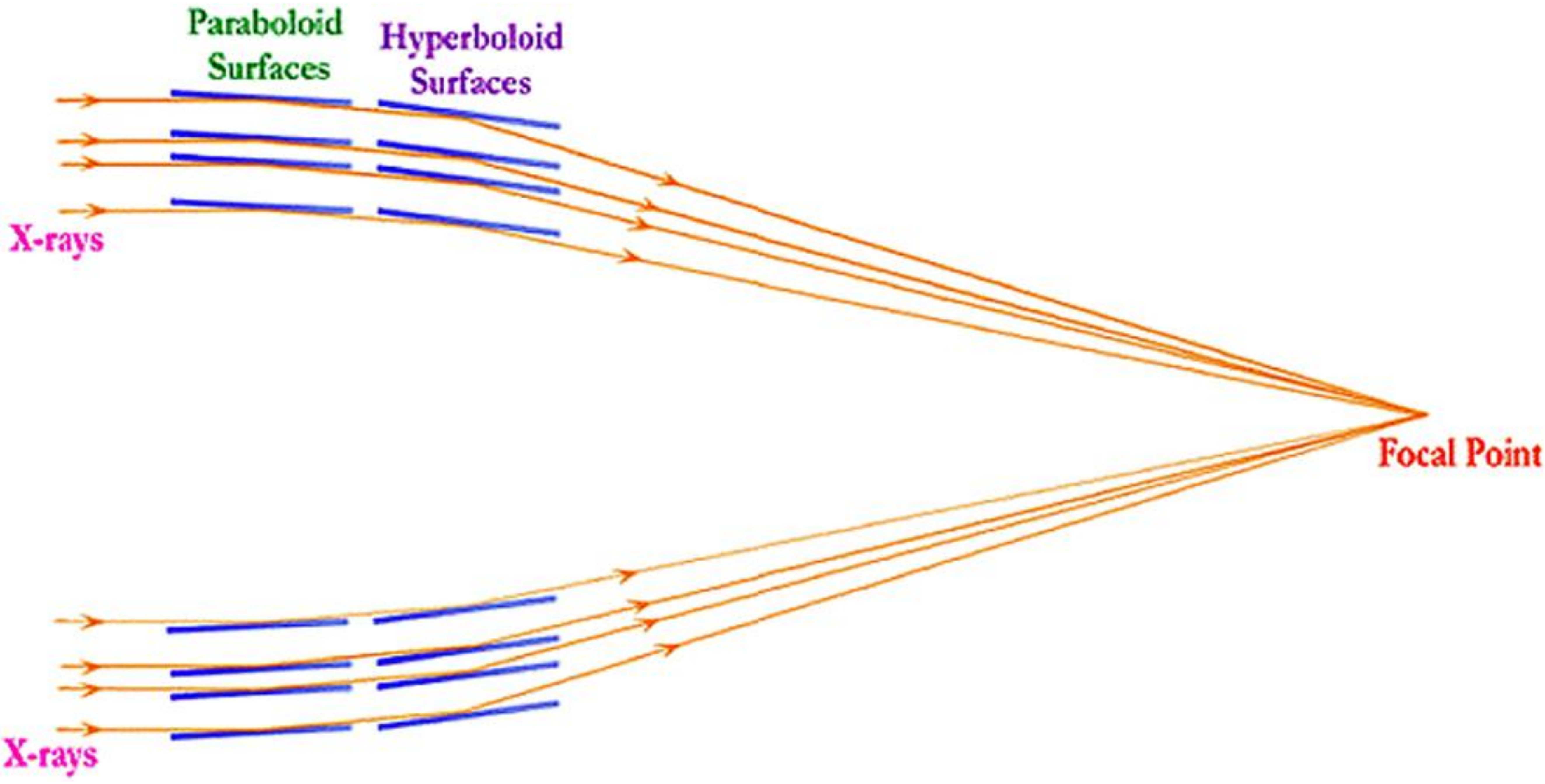




Come focalizzare la luce X

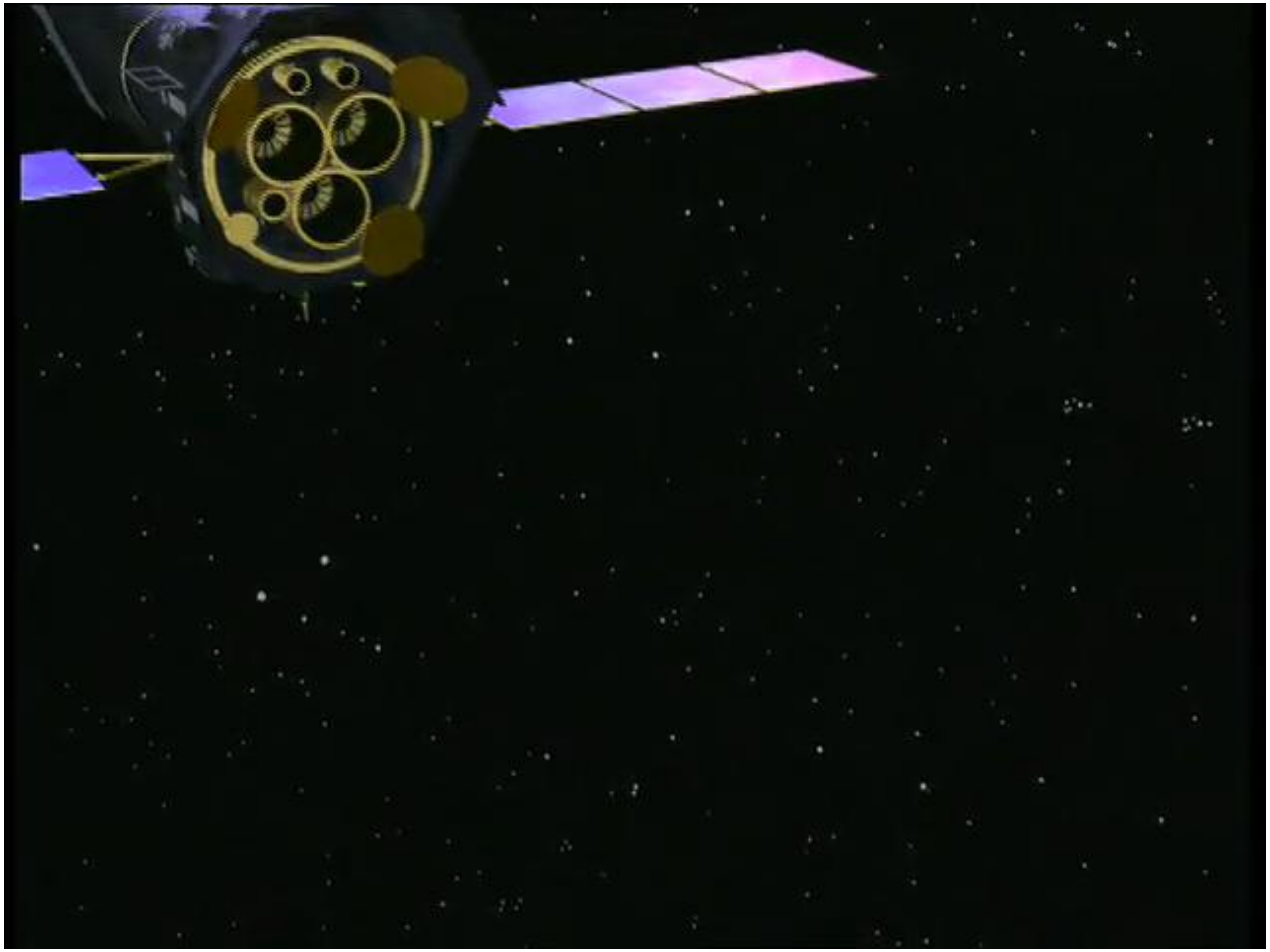


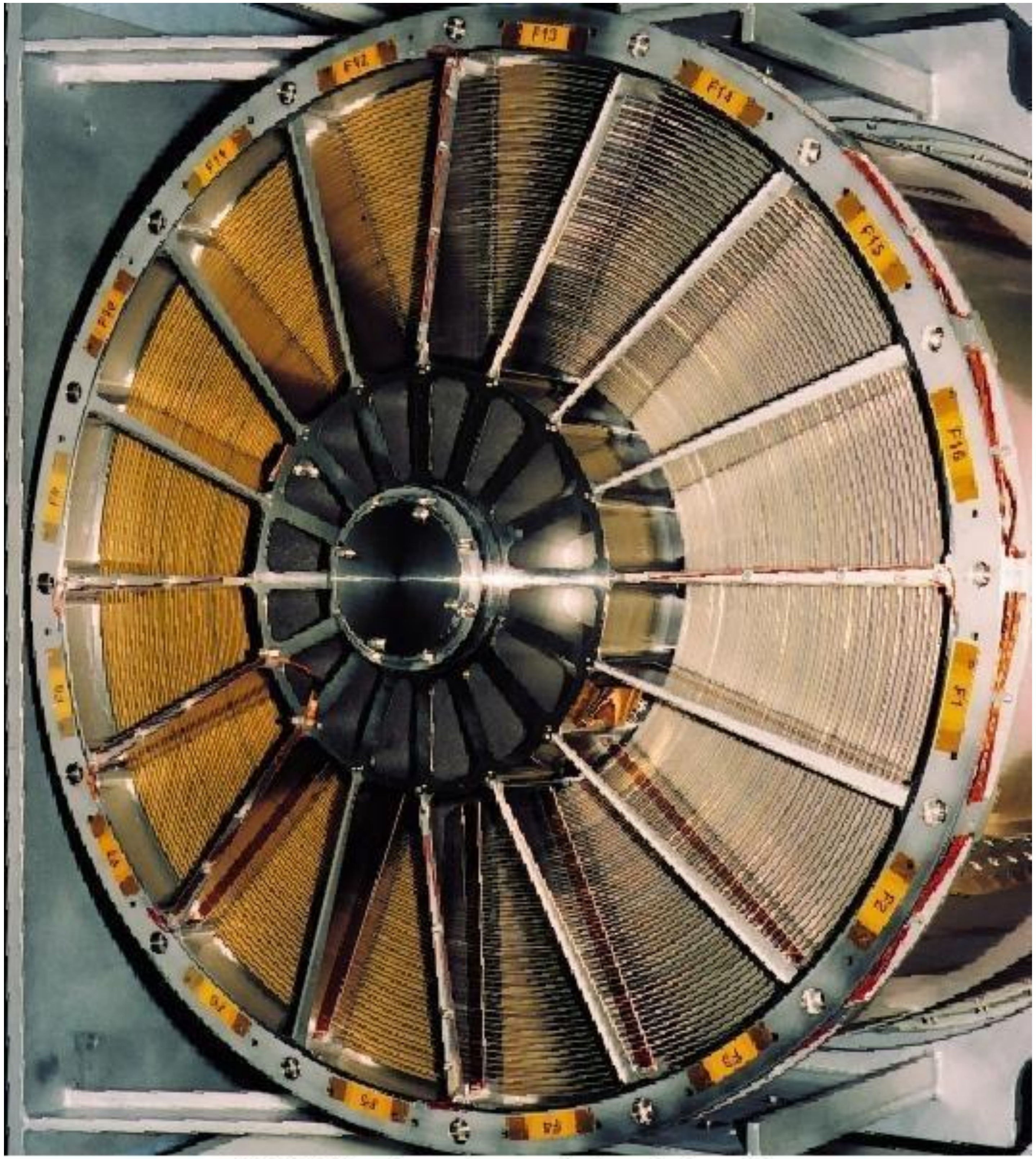
Il tipico disegno di un telescopio X



Video time!
X-ray vision

http://www.esa.int/spaceinvideos/Videos/2005/05/Stories_from_XMM-English

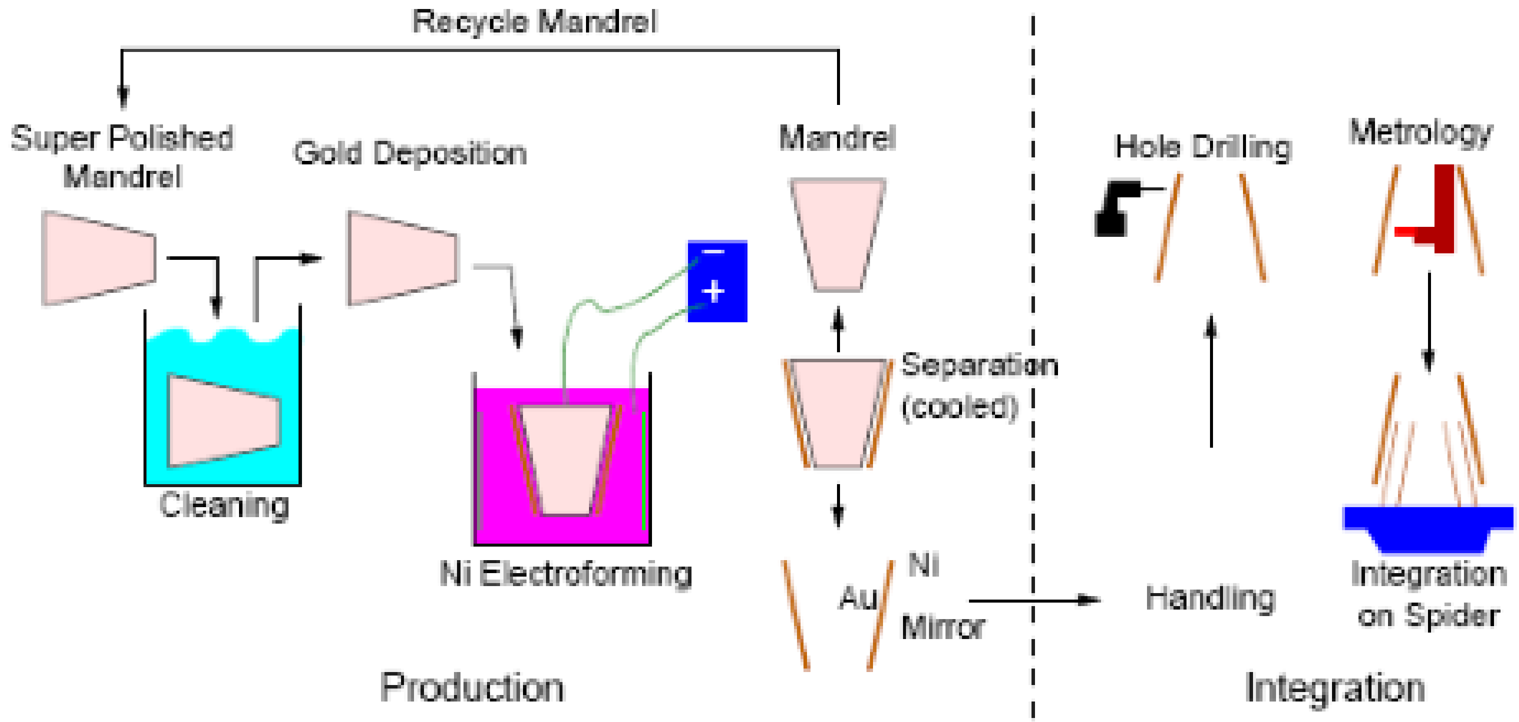




XMM-Newton mirrors during integration

Image courtesy of Dornier Satellitensysteme GmbH

European Space Agency



(after ESA)

Recipe for making an X-ray mirror:

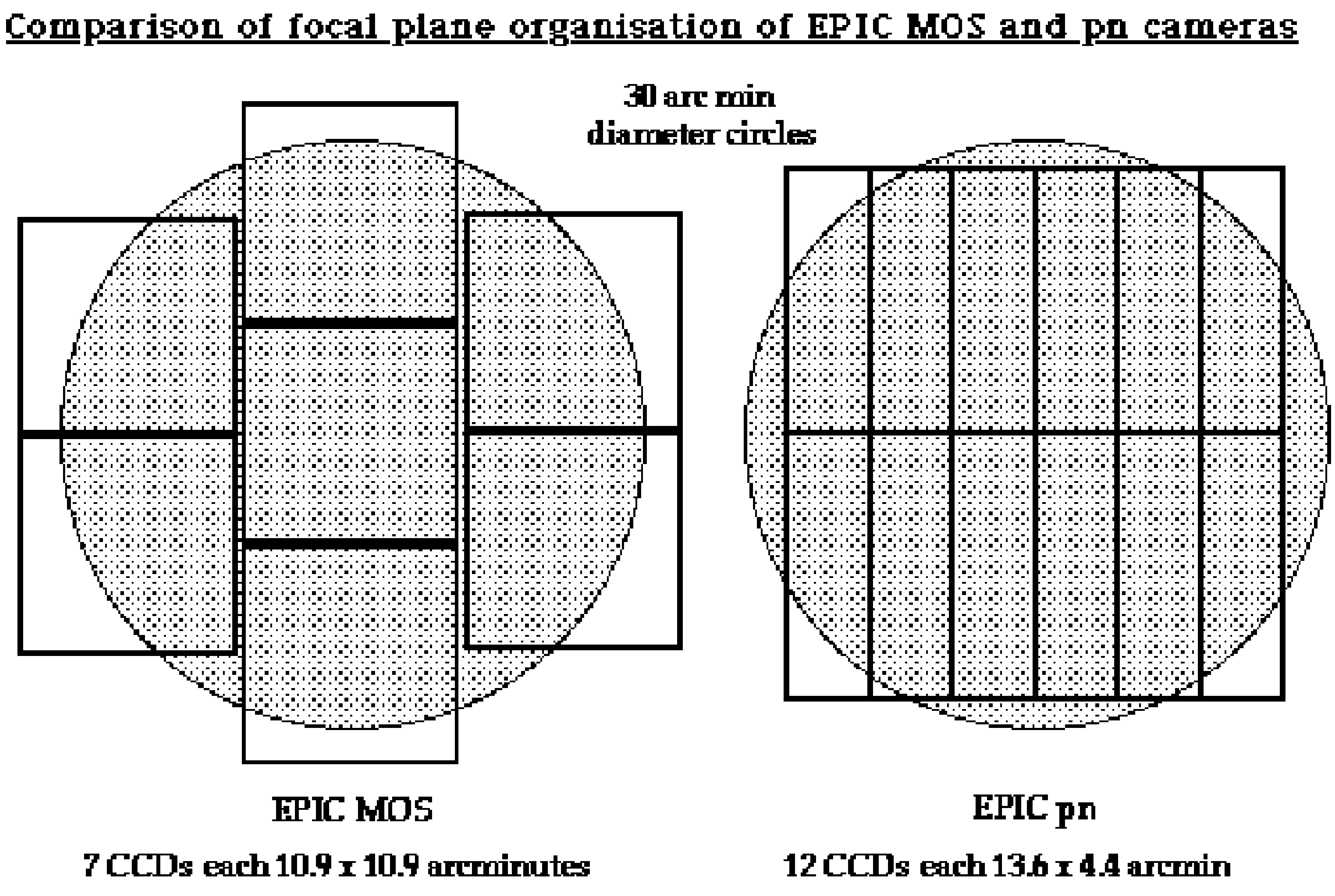
1. Produce mirror negative (“Mandrels”): Al coated with Kanigen nickel (Ni+10% phosphorus), super-polished [0.4 nm roughness]).
2. Deposit 250 nm Au onto Mandrel
3. Deposit 1 mm Ni onto mandrel (“electro-forming”, 10 μm/h)
4. Cool Mandrel with liquid N. Au sticks to Nickel
5. Verify mirror on optical bench.

Total production time of one mirror: 12 d, for XMM: 3×58 mirrors.

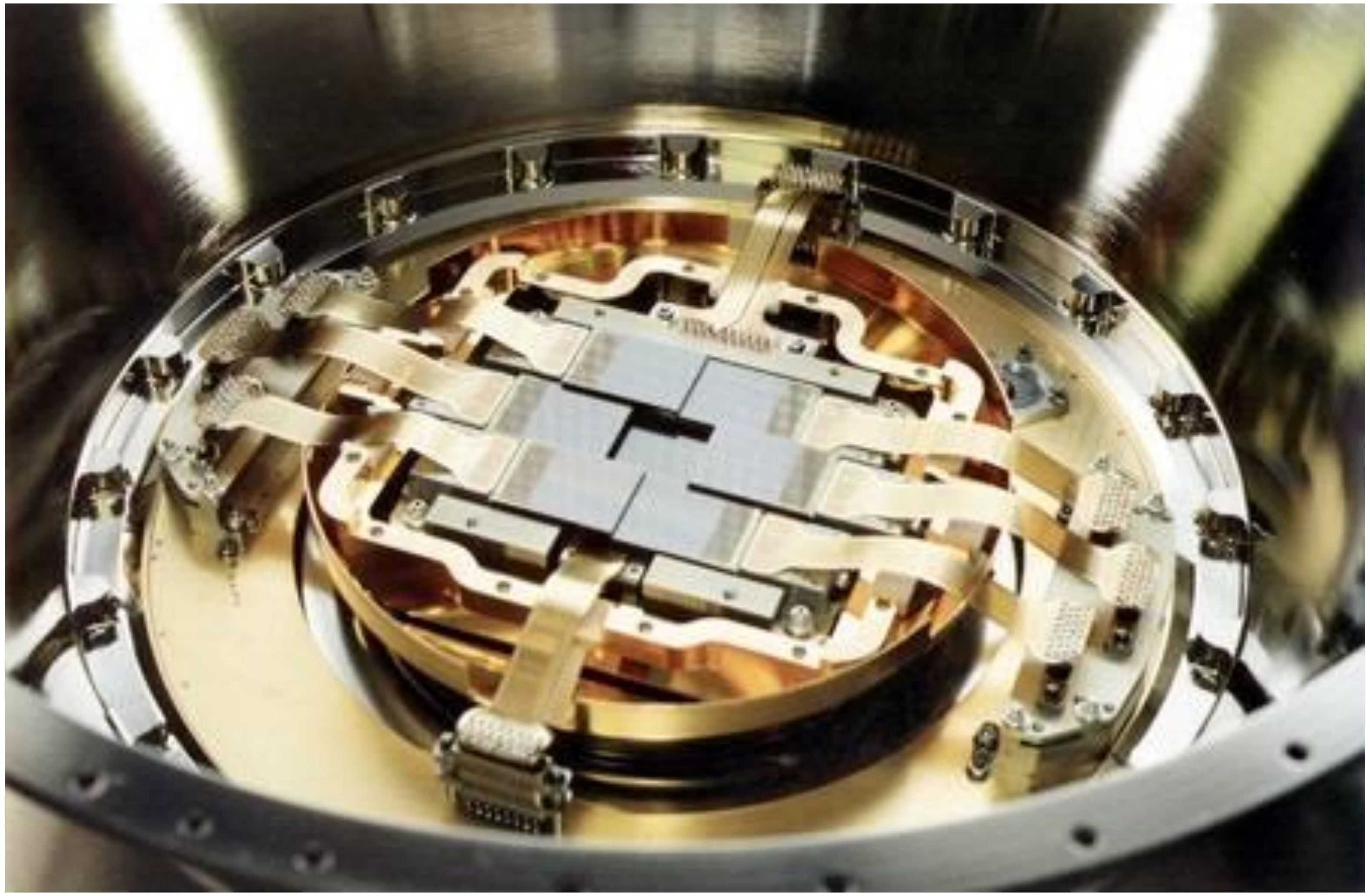
Video time!
Golden eyes

http://www.esa.int/spaceinvideos/Videos/2005/05/Stories_from_XMM-English

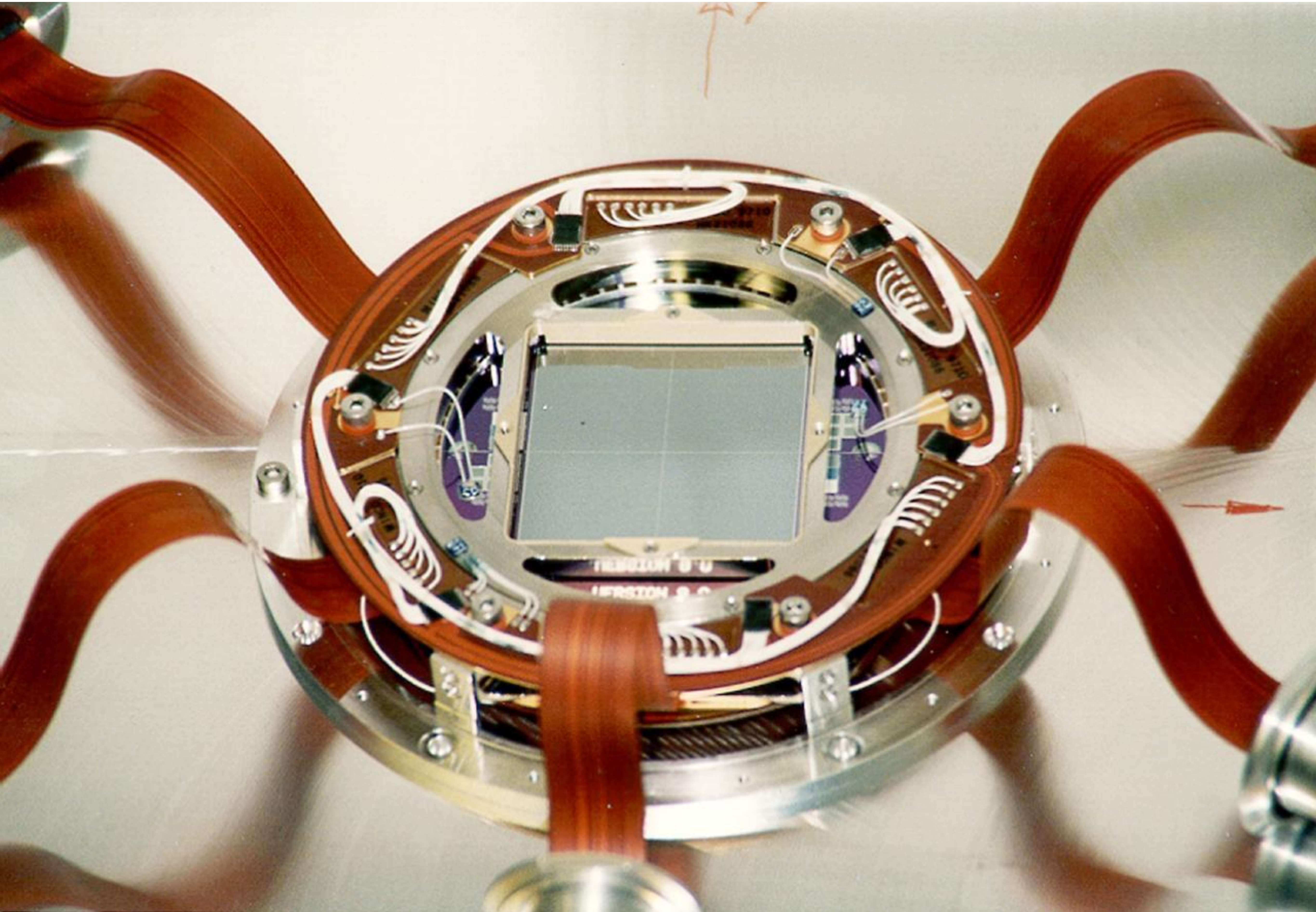
Lo strumento EPIC di XMM-Newton



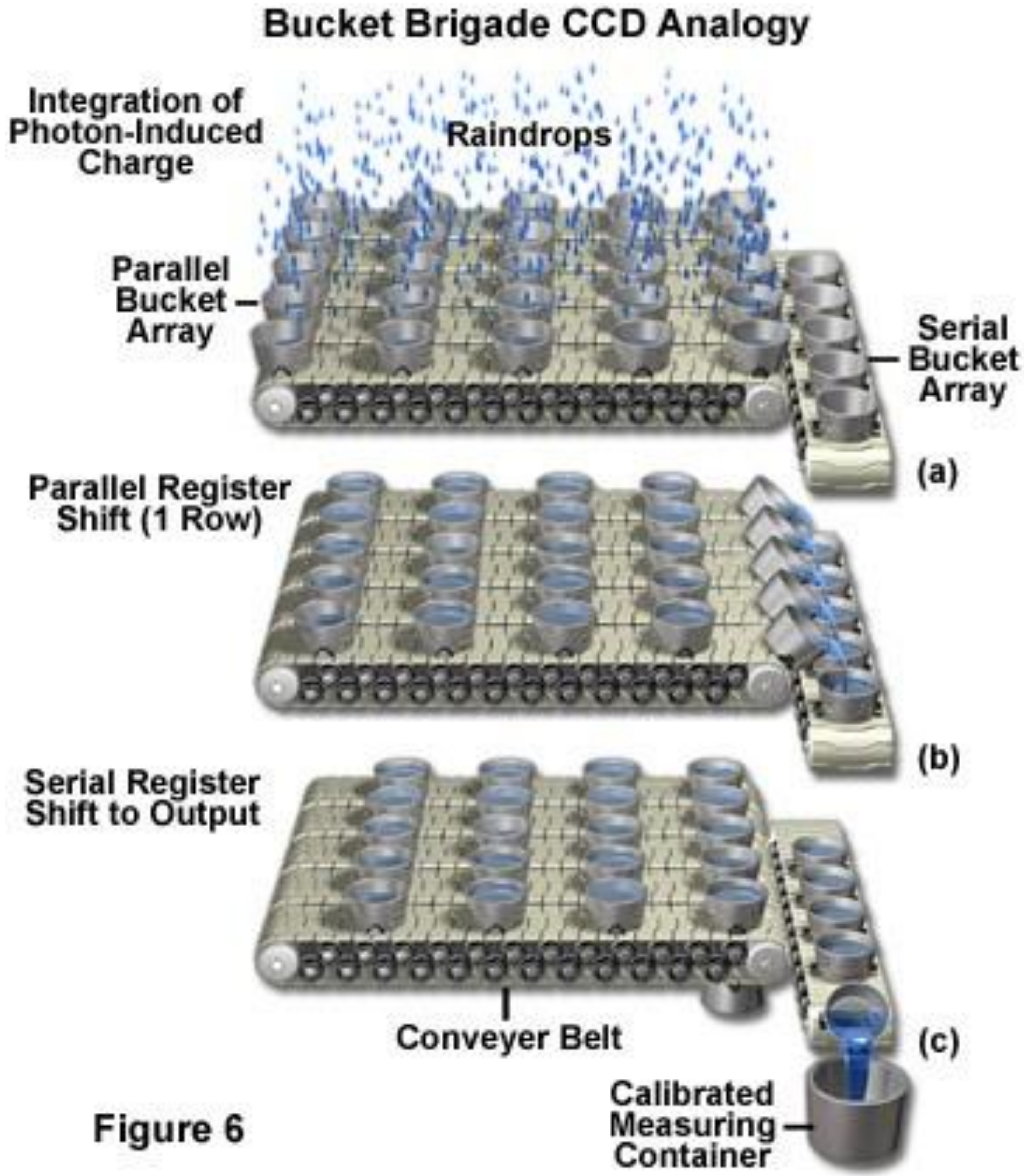
Una delle camere MOS

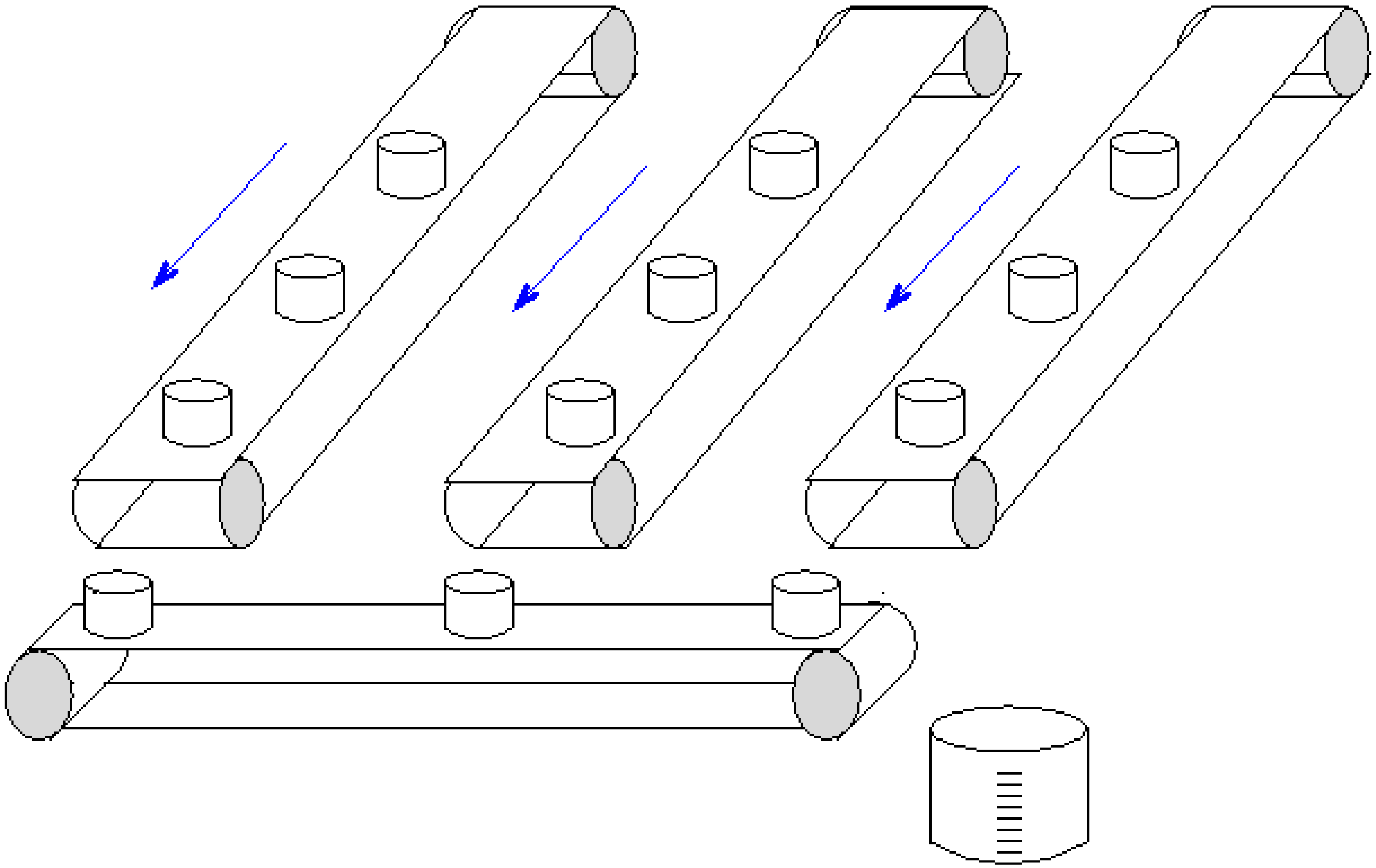


La camera pn



Come funziona un CCD per astronomia X





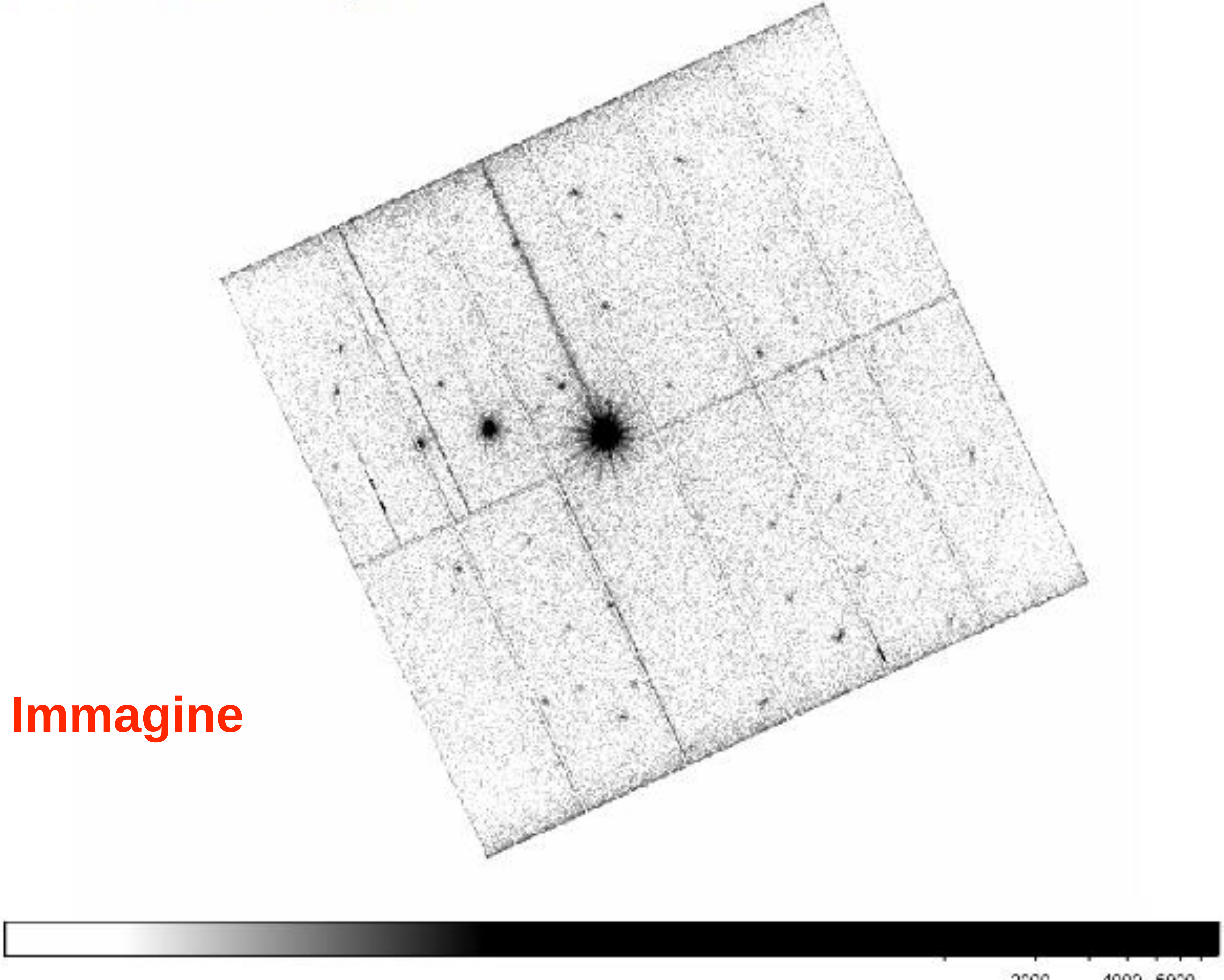
- Strumento con capacità imaging (CCD)
- Raccolgo lista di “eventi”
- Un evento: t, E, x, y

- Eventi :
  1. fotoni, da sorgenti (puntiformi, diffuse, fondo diffuso)
  2. non-fotoni (background “strumentale”)

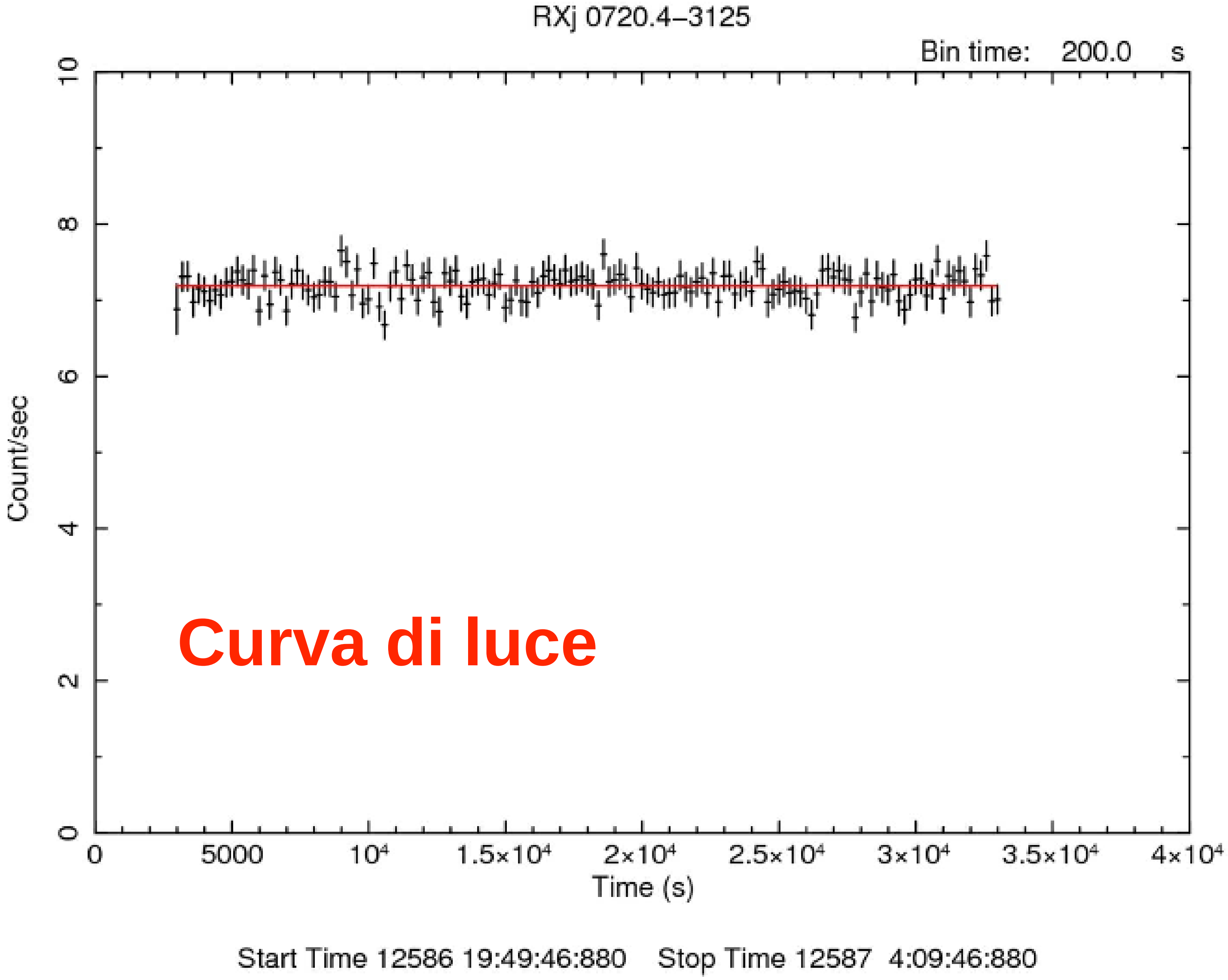
- Energia dei fotoni
- Tempo di arrivo
- Posizione (direzione di arrivo)

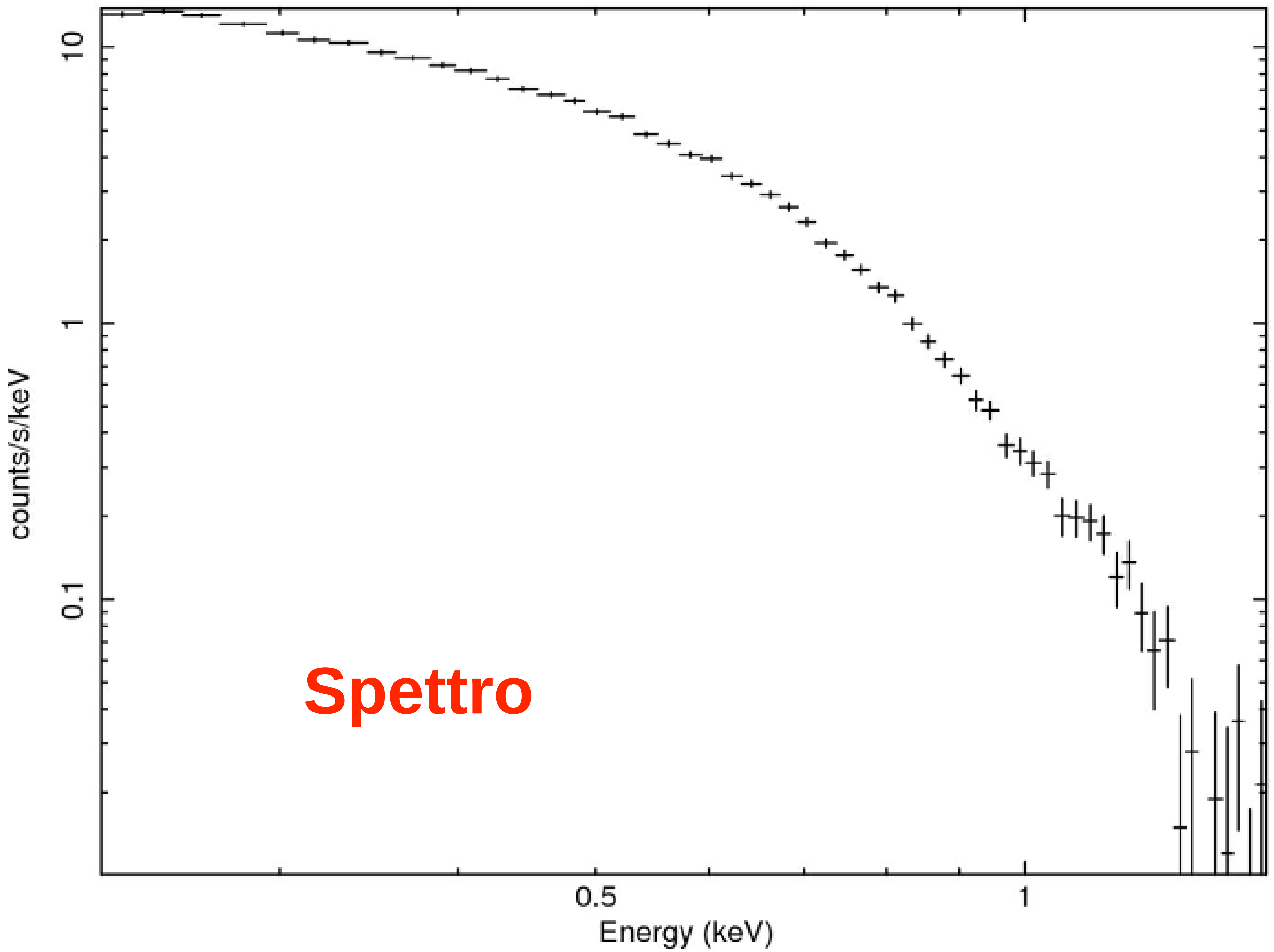
Come sfruttiamo queste informazioni?

XMM EPIC/pn



Immagine


RXj 0720.4−3125
Bin time: 200.0 s
Count/sec
Time (s)
0
2
4
6
8
10
0
5000
10⁴
1.5×10⁴
2×10⁴
2.5×10⁴
3×10⁴
3.5×10⁴
4×10⁴
Curva di luce
Start Time 12586 19:49:46:880 Stop Time 12587 4:09:46:880

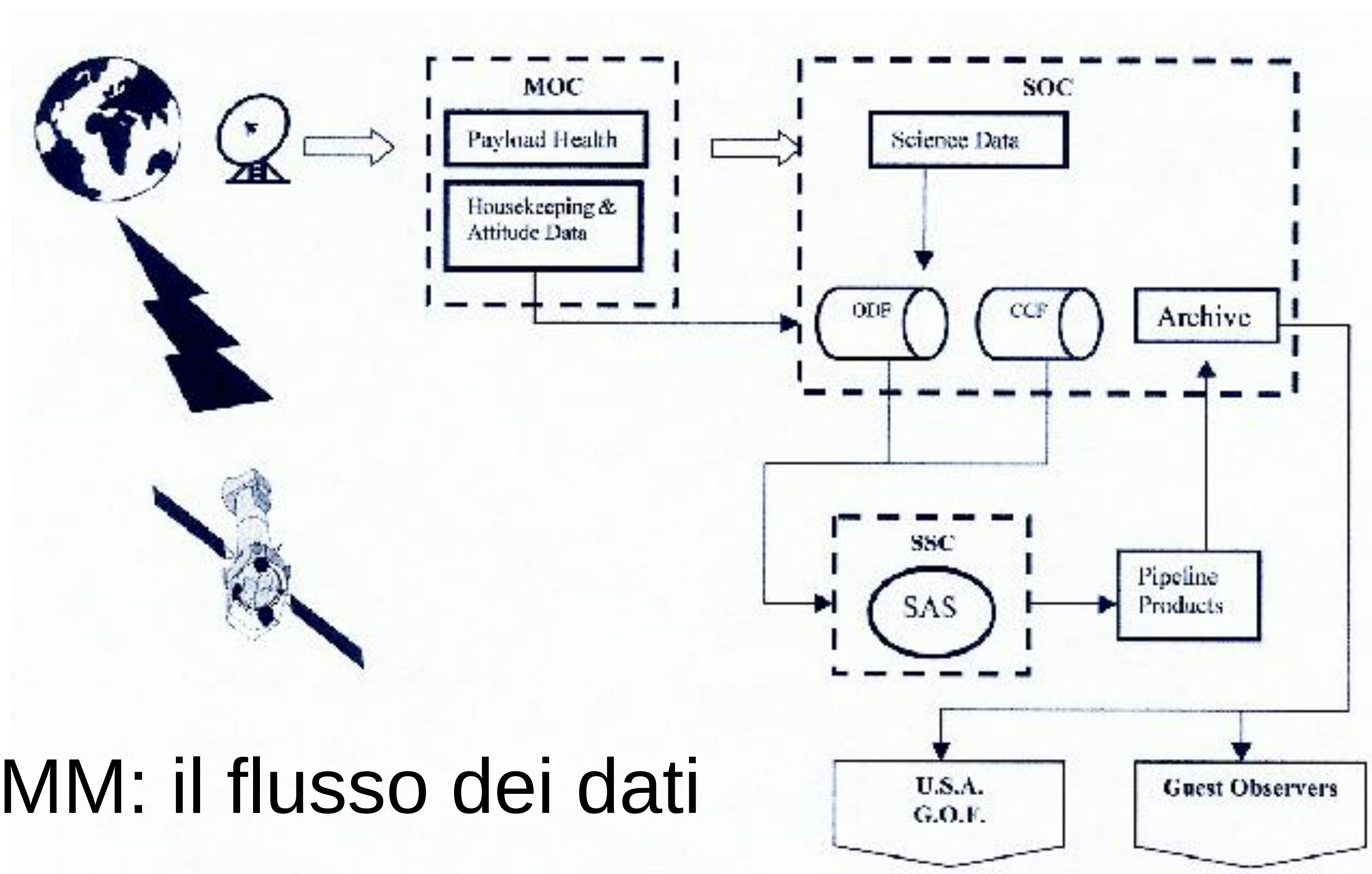


Spettro

XMM e' un osservatorio spaziale

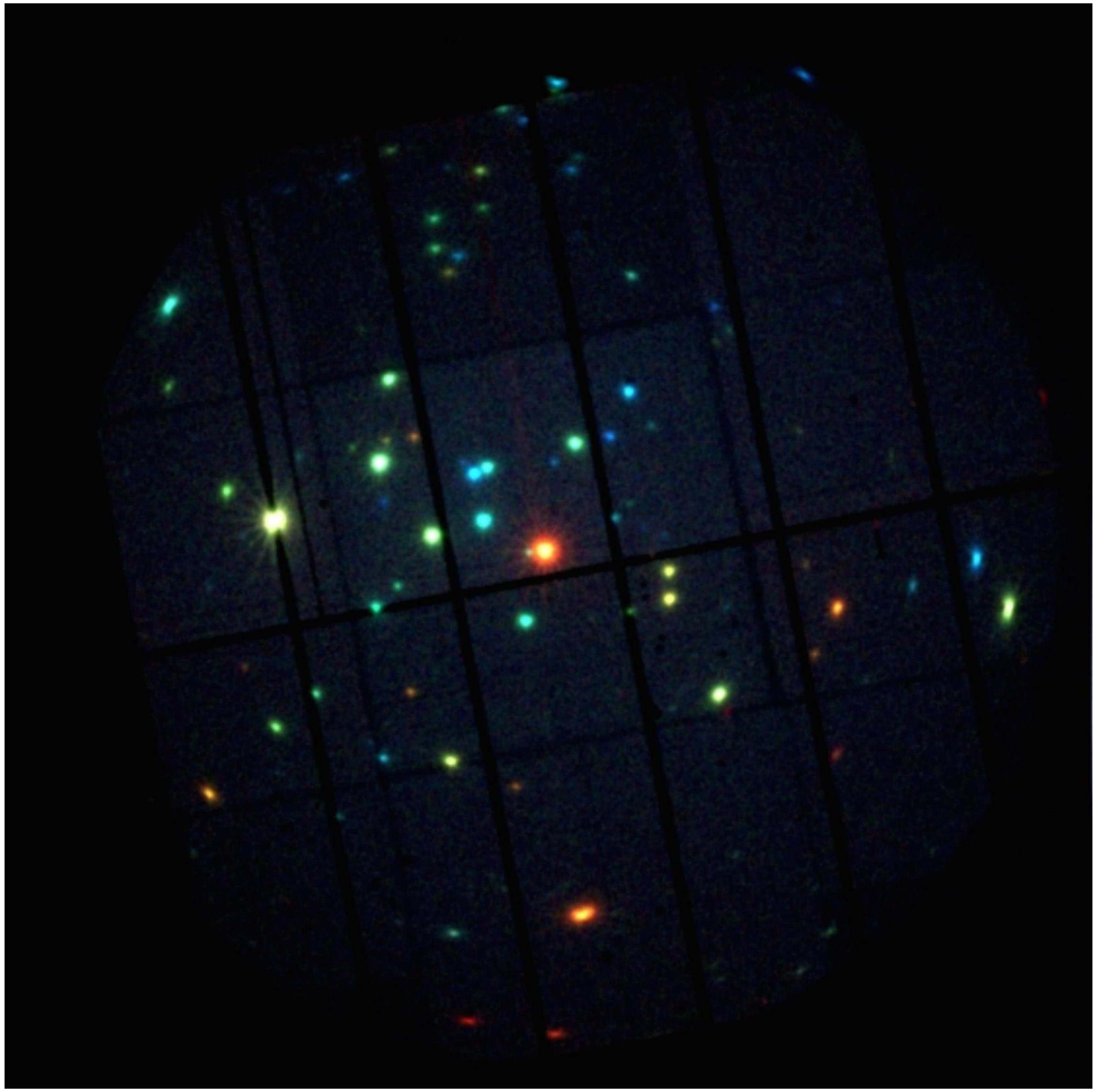
Bando per il tempo osservativo

Dati pubblici dopo 1 anno



XMM: il flusso dei dati

La scienza *serendipita*



Scoperte "fortuite" in astronomia: esempi famosi (3 premi Nobel)

L'astronomia X nasce con 2 scoperte serendipite nella stessa osservazione

The EPIC database: pointed observations

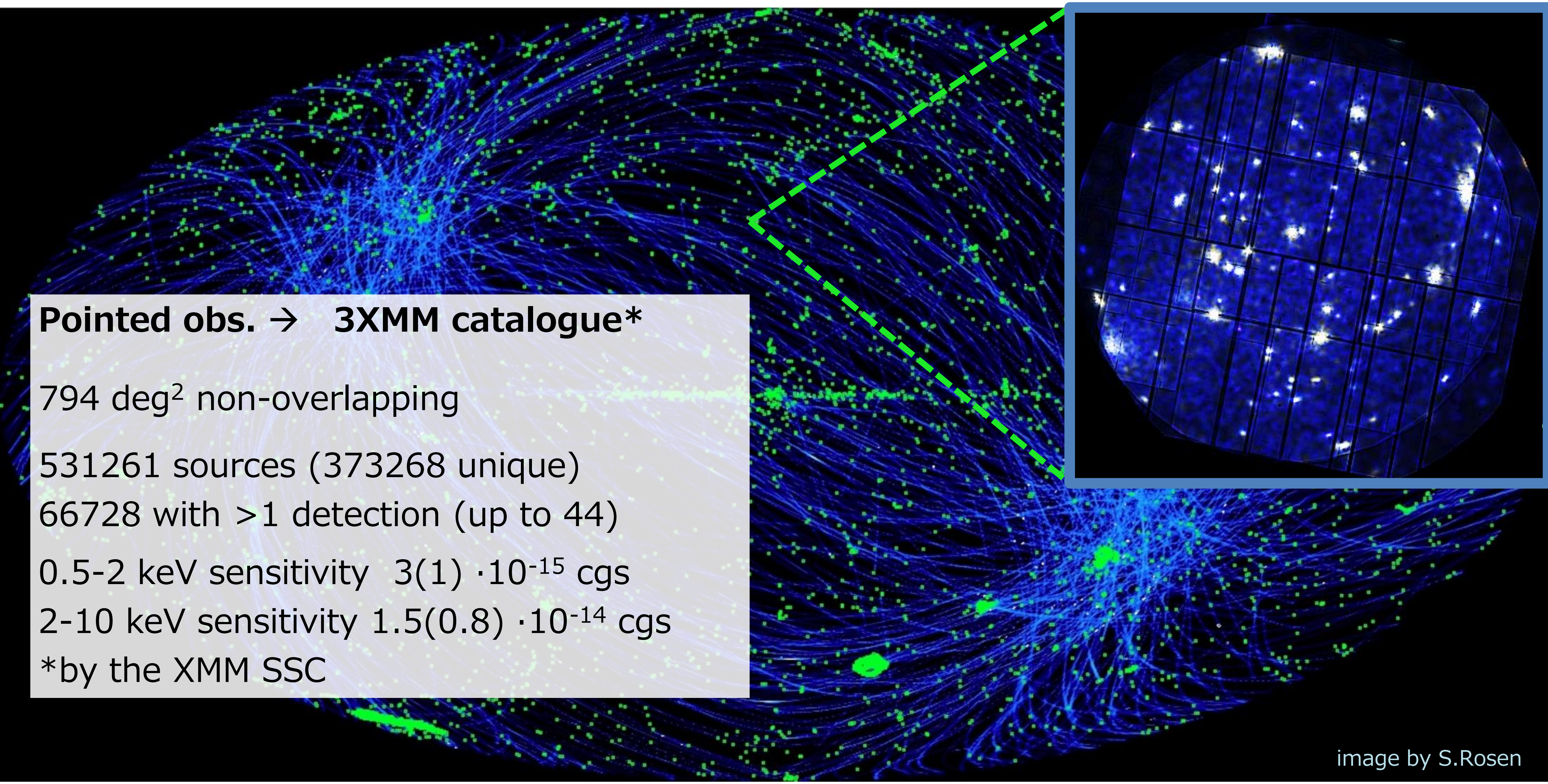


image by S.Rosen

Pointed obs. → 3XMM catalogue*

794 deg^2 non-overlapping

531261 sources (373268 unique)

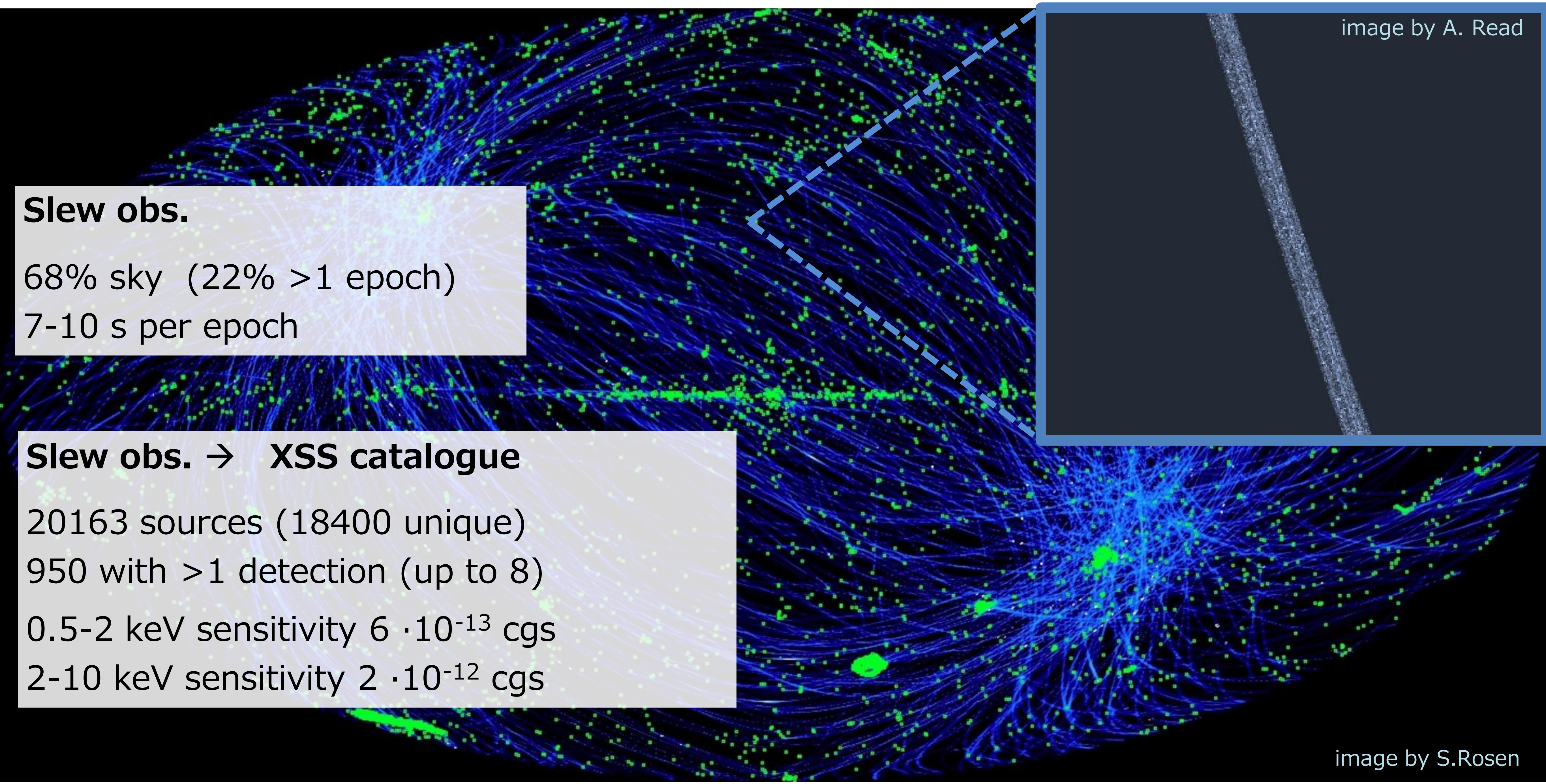
66728 with >1 detection (up to 44)

0.5-2 keV sensitivity 3(1) $\cdot 10^{-15}$ cgs

2-10 keV sensitivity 1.5(0.8) $\cdot 10^{-14}$ cgs

*by the XMM SSC

The EPIC database: slew data



Slew obs.

68% sky (22% >1 epoch)
7-10 s per epoch

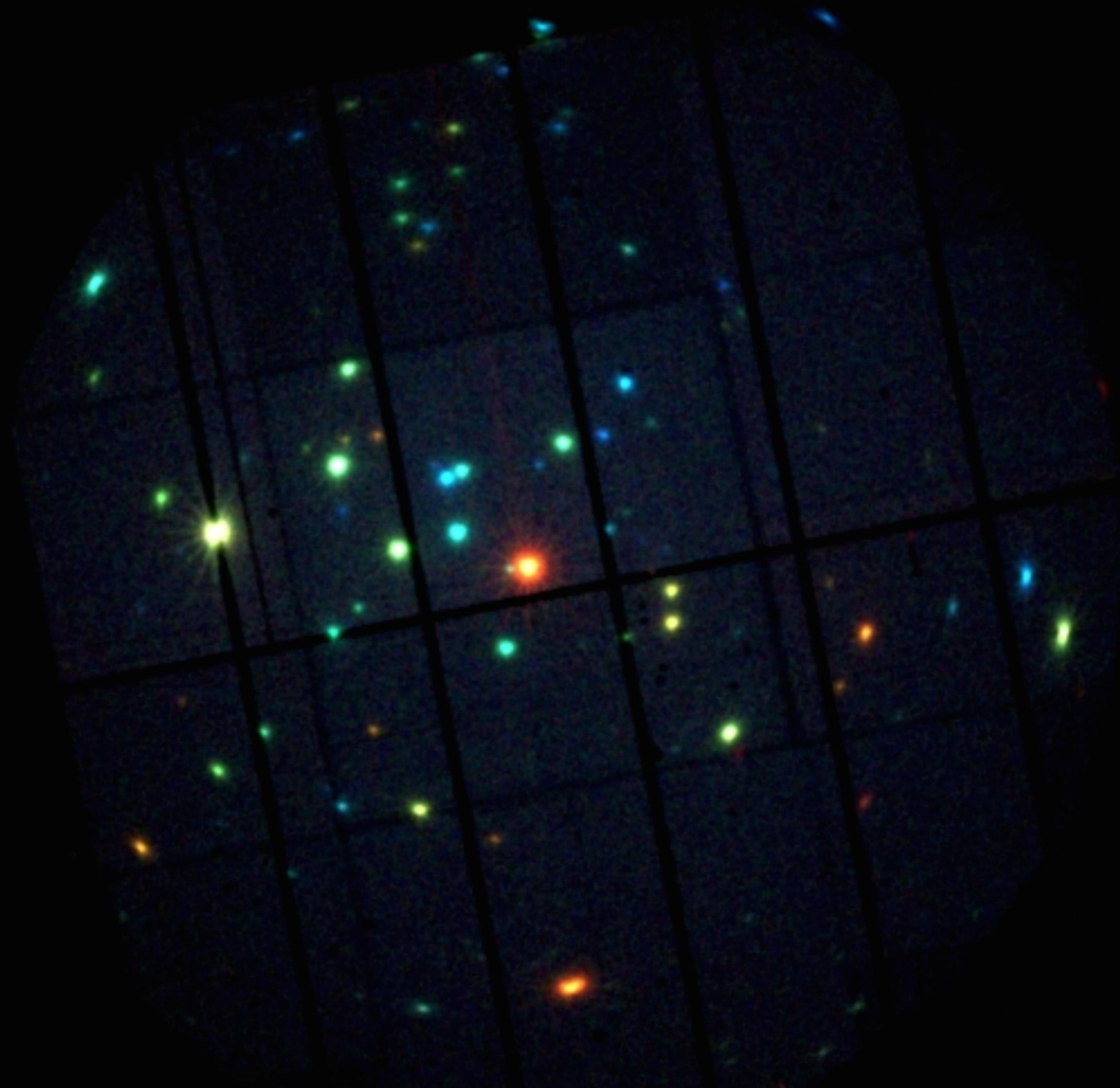
Slew obs. → XSS catalogue

20163 sources (18400 unique)
950 with >1 detection (up to 8)
0.5-2 keV sensitivity $6 \cdot 10^{-13}$ cgs
2-10 keV sensitivity $2 \cdot 10^{-12}$ cgs

Resta qualcosa da fare?

EXTraS

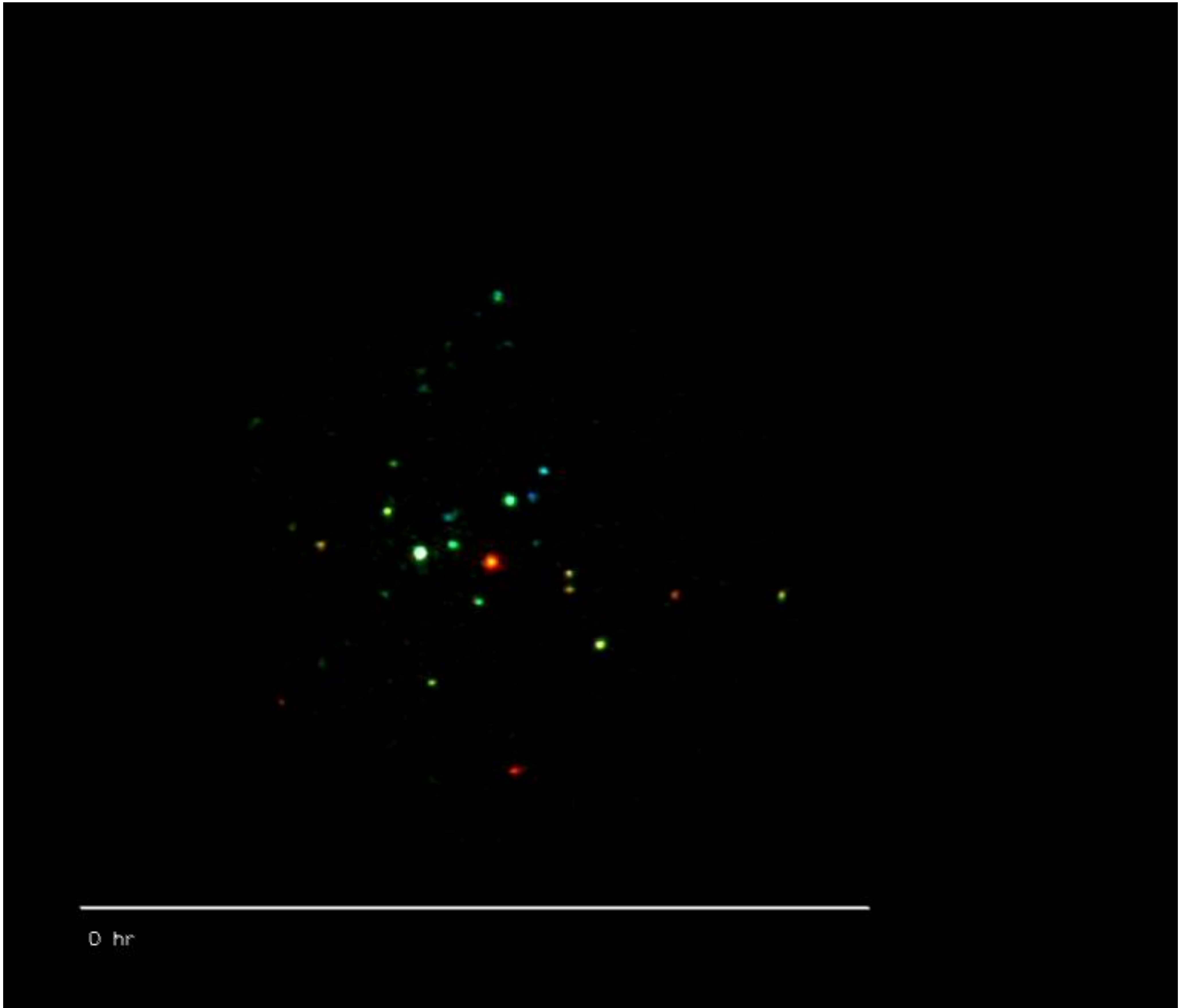
Exploring the **X**-ray **Tra**nsient and variable **S**ky



Cosa e’ stato “catalogato” di queste sorgenti?

Video time: droxo movie

http://xmm.esac.esa.int/external/xmm_science/gallery/images/droxomovie.mpg



Astronomia nel dominio temporale

“Variability pervades the cosmos.
Studies of variability dominate research in astronomy and astrophysics
and are so common that very many groups, projects and instruments
are dedicated to the examination of just one form of variability,
or one aspect of its diverse manifestations.”

manifest of IAU Symposium 285, "New Horizons in Time Domain Astronomy",
University of Oxford September 19-23, 2011

Come e’ nato EXTraS

- variabilita’ cruciale per capire sorgenti
- variabilita’ presente in tutte le sorgenti in banda X
- dati serendipiti EPIC: miniera ancora da sfruttare

L’occasione

il bando “Spazio” di FP7

Il consorzio EXTraS

Brevissima storia di EXTraS

- idea: estate 2012
- costituzione consorzio: settembre 2012
- proposta sottomessa il 26 novembre 2012
- progetto selezionato a marzo 2013
- contratto firmato agosto 2013
- inizio lavori gennaio 2014

EXTraS in breve

The most sensitive and complete investigation of variability in the soft X-ray sky

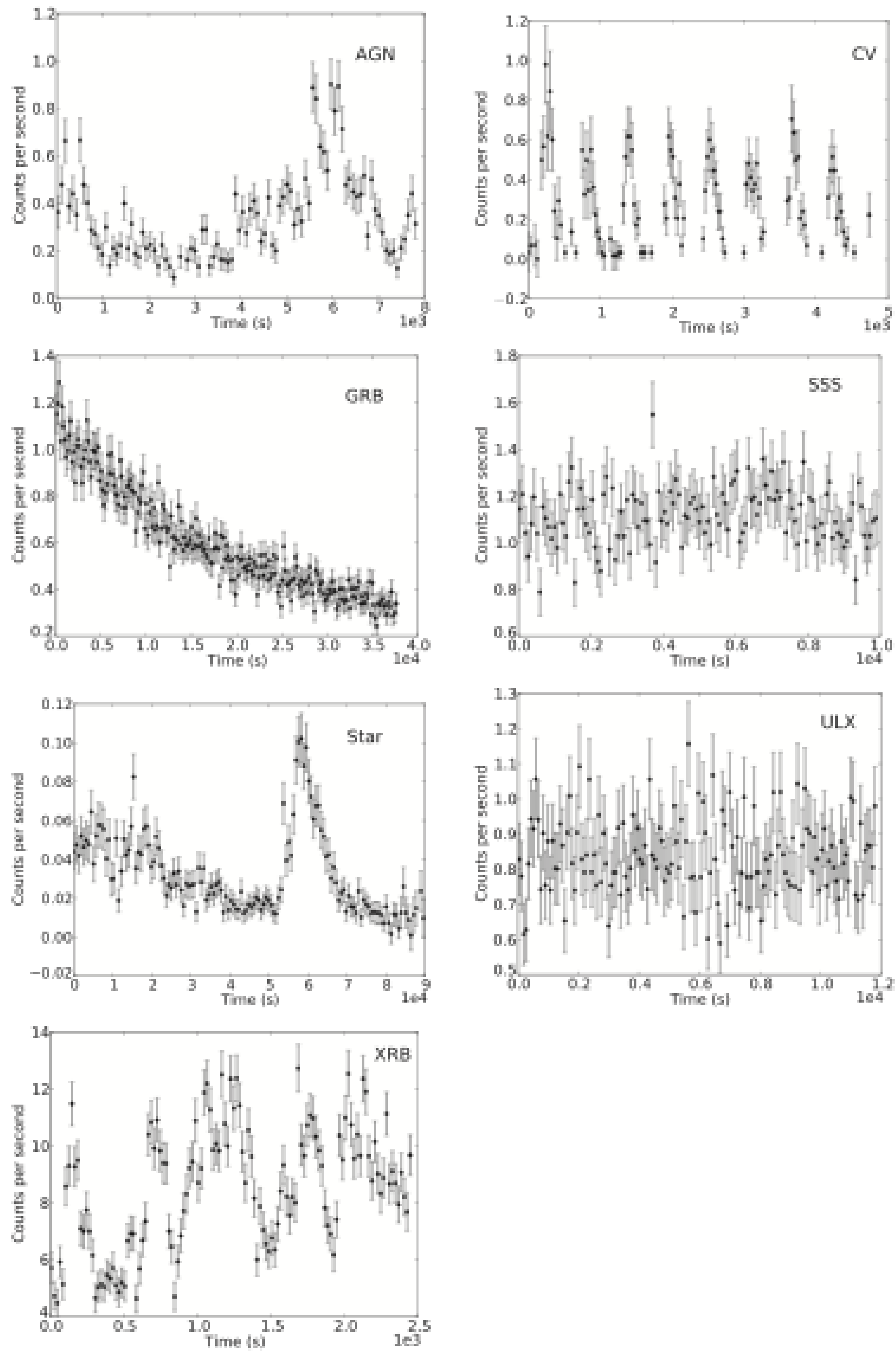
- explore the **serendipitous** content of the **XMM-Newton/EPIC** database in the **time domain**
- make it **available and easy to use** to the whole **community**.
- allow to do **more, new science**

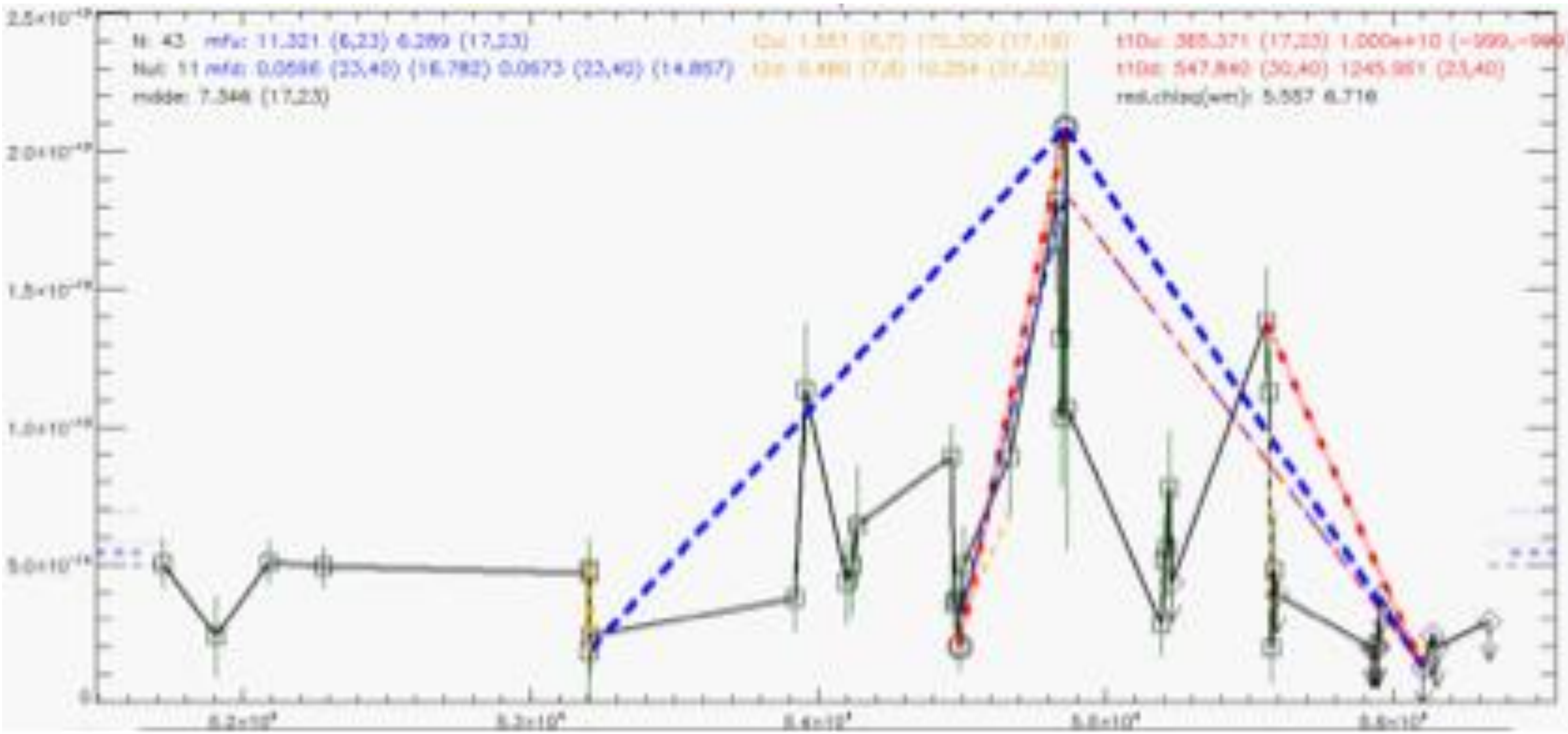
Cosa faremo in EXTraS

- **Variabilita’ non periodica**
- **Variabilita’ periodica (pulsazioni)**
- **Transienti**
- **Variabilita’ su lungo tempo scala**

Diversi esempi
di curve di luce
con diverse variabilita'

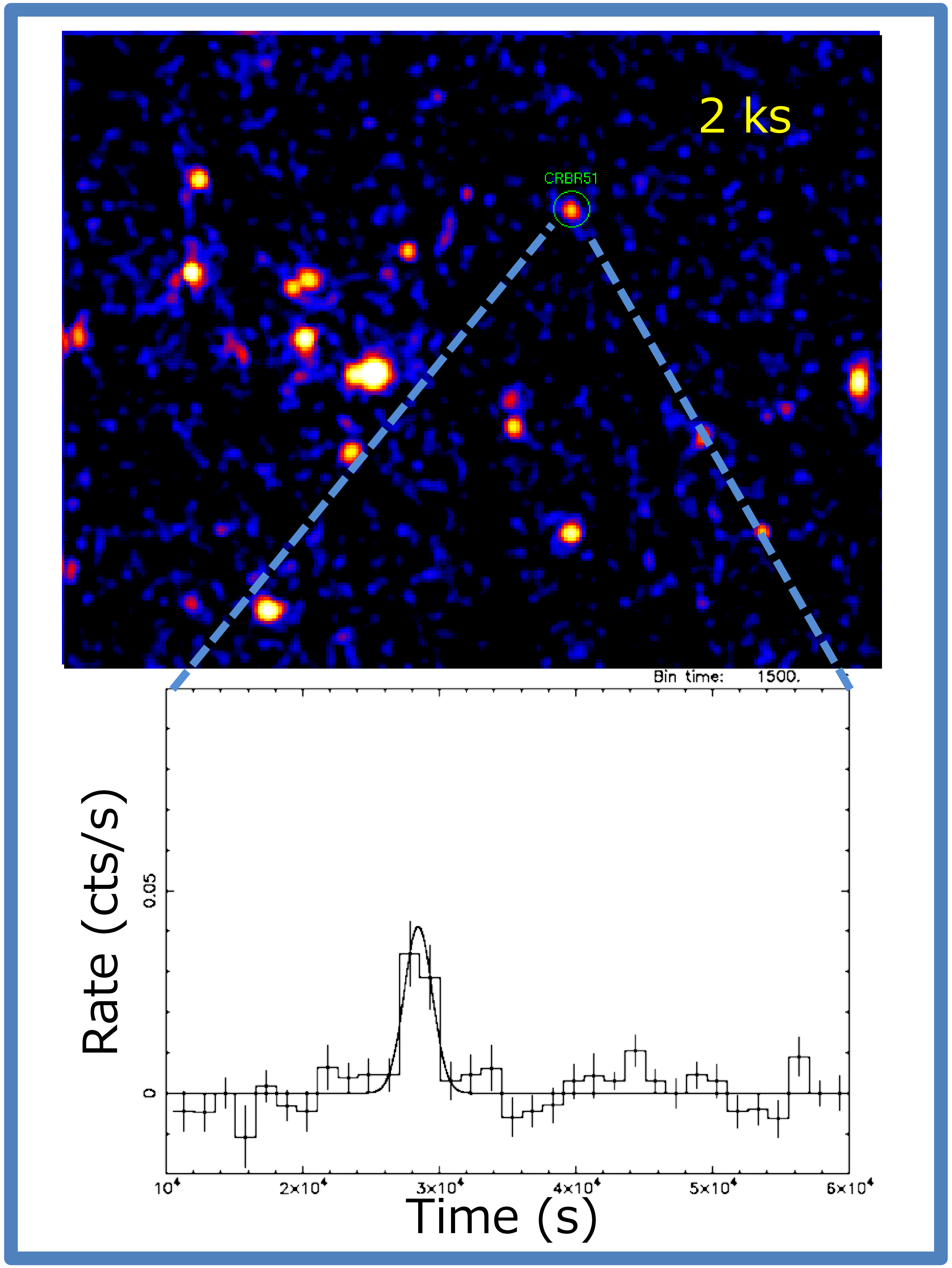
tempi scala
da minuti a ore



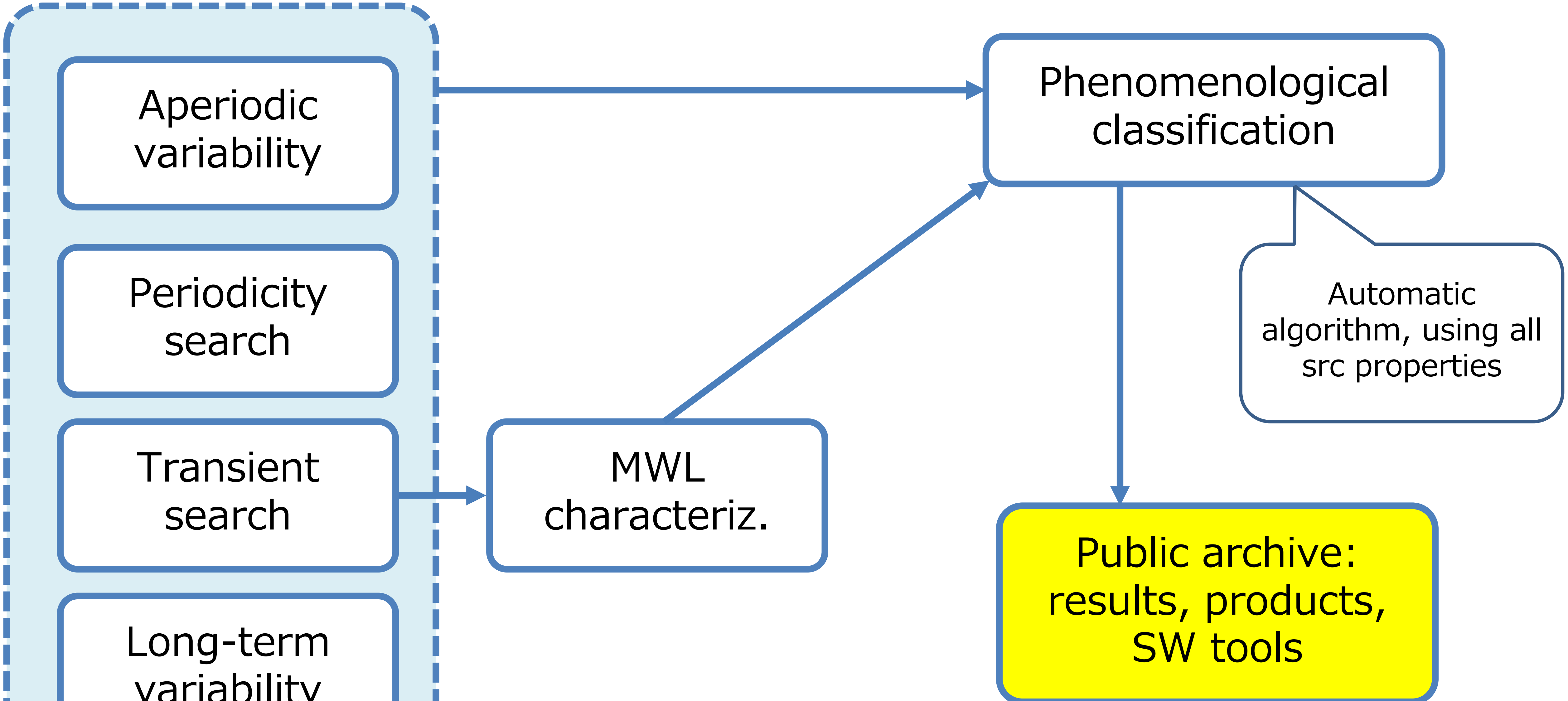


Una curva di luce estesa su 15 anni

Una sorgente “transiente”
visibile per soli 30 min



EXTraS: the output



EPIC data analysis

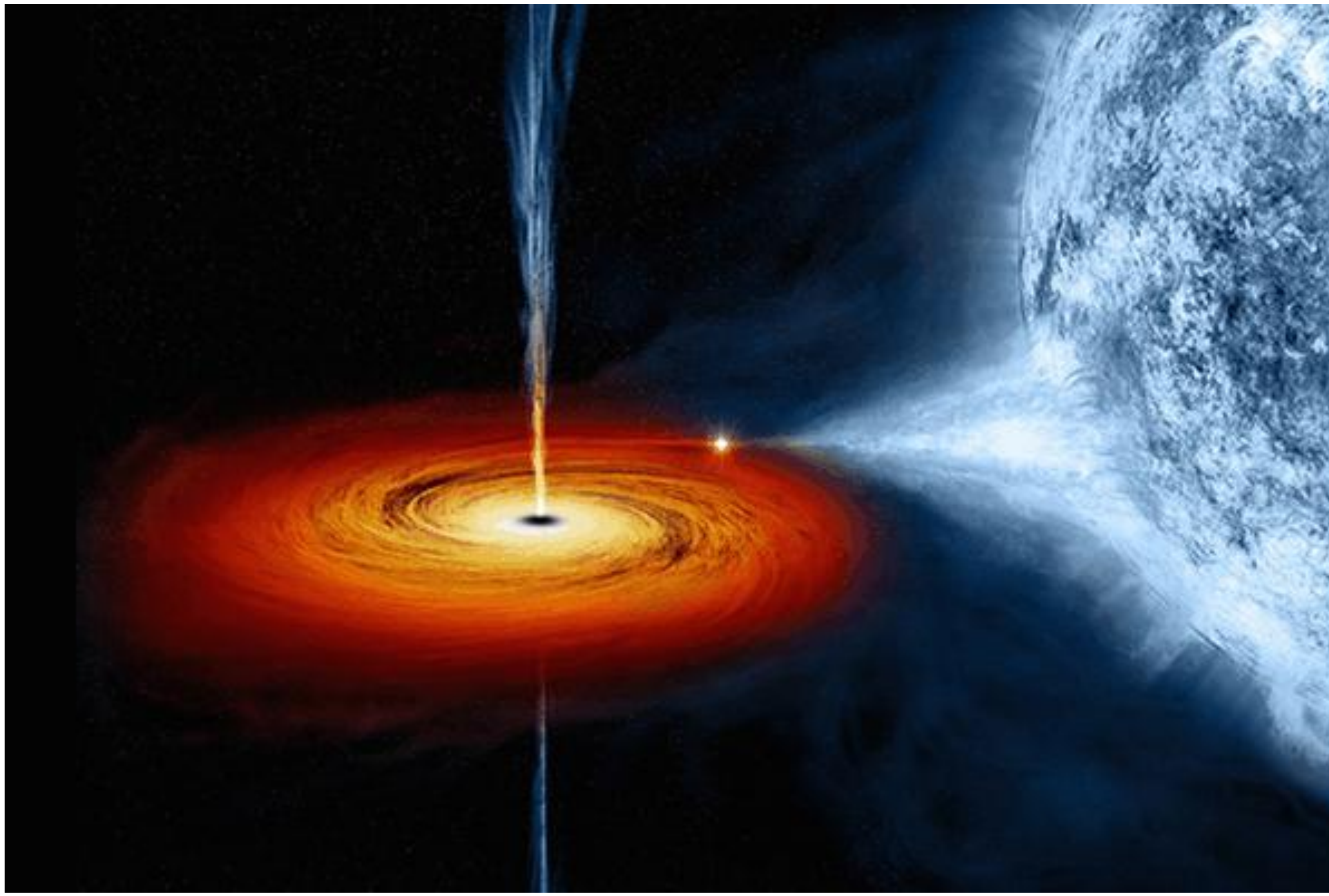
Release:
end of 2016

Le sorgenti di EXTraS

Tutte le sorgenti in banda X sono variabili

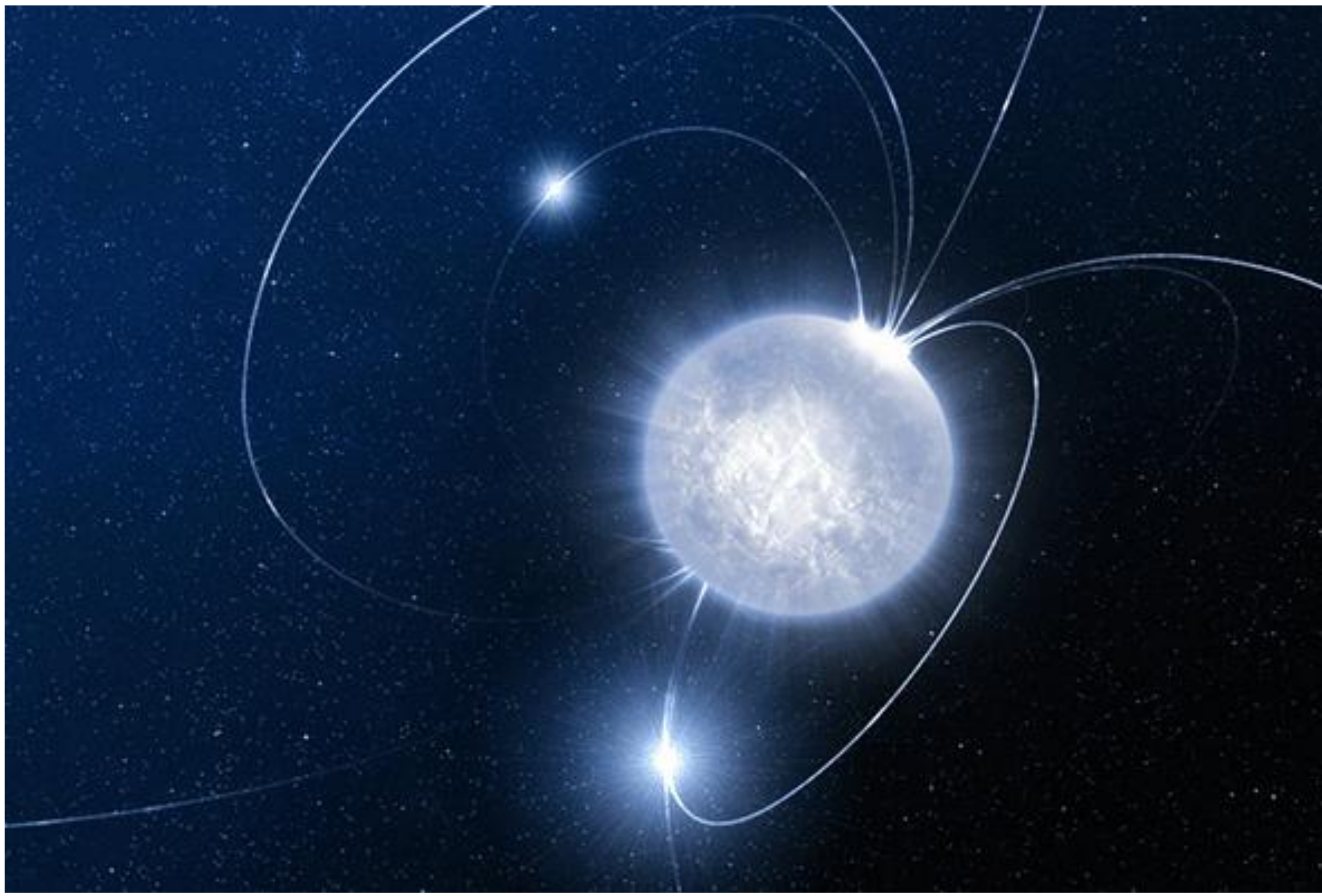
Stellar flares

X-ray flares from magnetically active, late-type stars, either isolated or in binary systems.



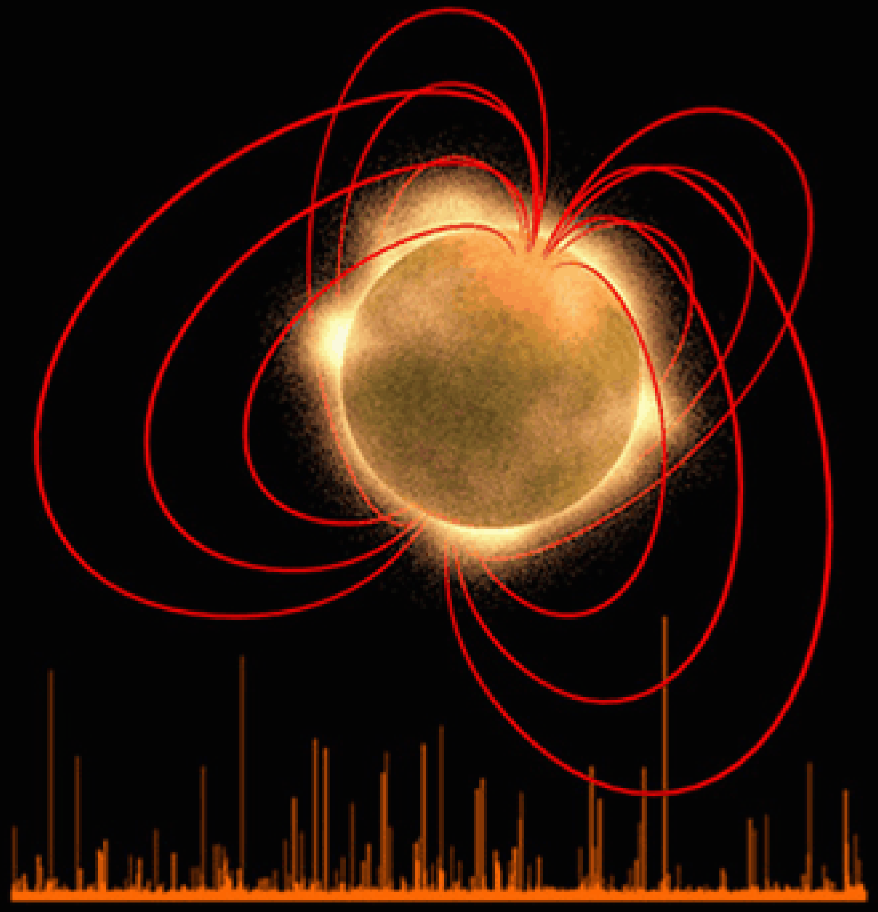
Transient X-ray binaries

Black holes, neutron stars or white dwarfs accreting matter from their stellar companion.



Magnetar

Magnetar is a type of neutron star with an extremely powerful magnetic field.

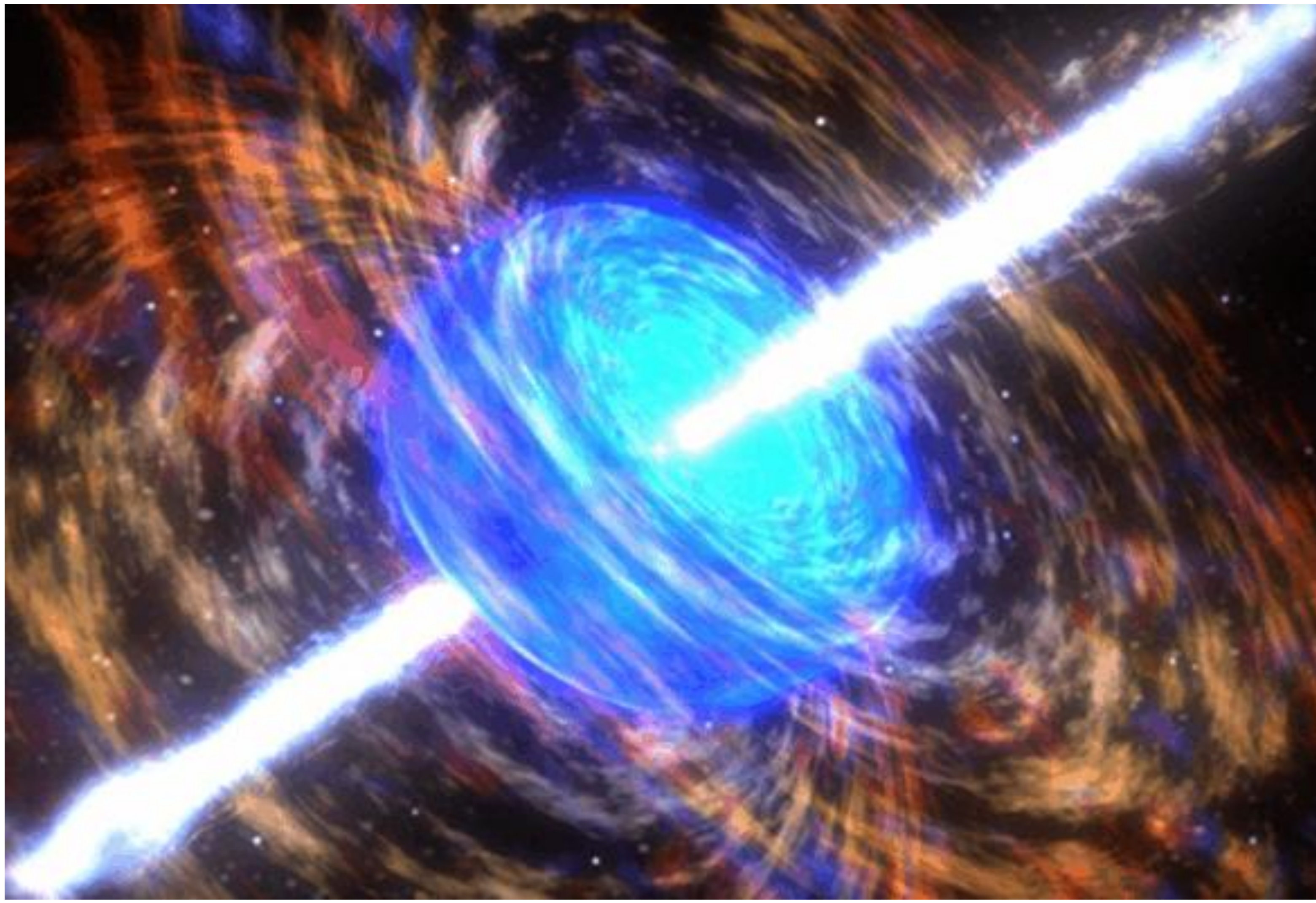


Soft gamma-ray repeaters (SGRs)

X-ray sources believed to be powered by magnetars, i.e. neutron stars with the strongest magnetic field in the Universe.

Tidal Disruption Event

Disruption of a star
by a massive black hole

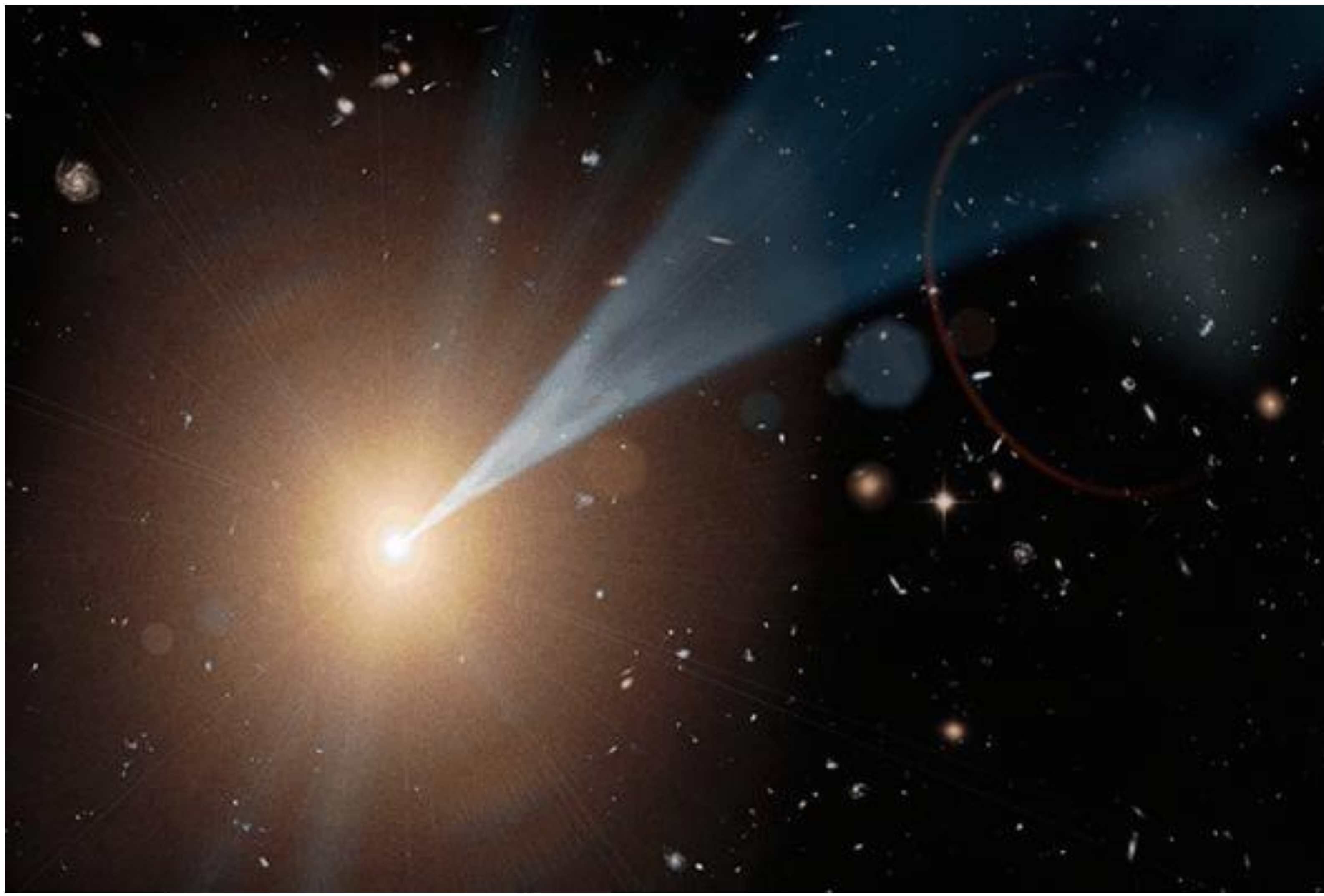


Gamma-ray bursts (GRBs)

The most powerful cosmic explosions, likely produced by the collapse of massive stars to black holes or by the coalescence of two neutron stars.

Supernova X-ray flashes

Produced by the supernova shock emerging from the exploding star.



Blazar flares

Gamma-ray flares produced by the jets of supermassive black holes at the centre of galaxies.

Some XMM-Newton history

- Mission was built for 2.25 years
- Mission was designed to be compatible with 10 year lifetime
- Before launch there was some 100 kg mass margin that was used to 'top up' the fuel
- Mission was built to be 24/7 controlled from ground – no intelligence – no significant command stack
- We launched with only 3 quadrants of EPIC-PN working ! (There's nothing like a good shake)

- I started working on XMM-Newton in 1988 – 26 years ago → Knowledge management is an issue
  - Usually KM documents a design and what the system CAN do – not what it COULD be made to do

presentaz. F.Jansen, XRU 2014, Dublin